Recology
Yuba - Sutter
WASTE ZERO

January 31, 2014

Ms. Wendy Wyels
California Regional Water Quality Control Board
Central Valley Region
11020 Sun Center Drive, #200
Rancho Cordova, CA 95670-6114

RE: Compost Area Leachate Collection Work Plan, Feather River Organics, Yuba County, California
Cleanup and Abatement Order R-5-2013-0704

Dear Ms. Wyels:

Recology Yuba-Sutter (RYS) is submitting the attached Compost Area Leachate Collection Work Plan, on behalf of Feather River Organics (FRO). The plan was prepared and signed by Golder Associates Inc, as prescribed by Order 9 of the August 29, 2013 Cleanup and Abatement Order (CAO) R5-2013-0704. It is a follow-up to the October 31, 2013 Compost Area Workplan submitted per Order 5 in the referenced CAO.

Based on the preliminary water balance prepared by Golder Associates, a 4.3-acre lined retention basin as well as other system upgrades would be required to contain the liquids generated during a 100 year return period. Preliminary cost estimates lead Recology to the conclusion that more detailed evaluation of this option is warranted for a system of this magnitude. As noted in the attached Golder report, prior to construction of this system, permitting and other regulatory approvals, CEQA analyses and local land use approvals will be required. Given the regulatory and technical complexities of designing and permitting the above noted system as well as the significant financial burden it would place on the facility; RYS also feels that an evaluation of alternative options will be necessary prior to a final determination and recommendation regarding any permanent solution for controlling liquids at the site.

As a practical matter, since the interim leachate collection and management system was installed in Fall 2013, RYS has been unable to evaluate the effectiveness of this new collection system due to the lack of rainfall during the 2013-2014 rainy season. As a result, the performance capabilities of the current system are unknown. The potential cost impacts of implementing a permanent system and need to explore other viable engineering and operational options prevent Recology from committing at this time to a long-term conveyance and containment system.

Should a retention basin be deemed economically and technically feasible, Recology Yuba-Sutter estimates that additional time will be required to complete a CEQA review, obtain the necessary permits and land use approvals and enter contracts for the design and construction of a lined retention basin, presumably to be located in the Hog Farm. As a result, Golder has developed and RYS has proposed a schedule in the Work Plan that will require extending the October 1, 2014 construction completion date contained in the CAO. In addition, the Golder work plan provides a best case scenario timeline which, in

Recology's experience, is aggressive and may take longer than Golder has estimated due to regulatory review and approval processes. Should Recology determine that an alternative solution is more economically and technically feasible option, it is still likely that the October 1, 2014 timeline set forth in the CAO will be difficult to achieve due to necessary regulatory review and approval processes.

We request an opportunity to meet with you at your earliest convenience to discuss the results of Golder's analysis and to discuss with you the alternatives available to ensure the continuance of composting at FRO or alternate materials handling options available to Recology.

Until such a time that cost impacts and alternative options can be fully evaluated, RYS is committed to keeping the temporary leachate collection and containment system in place and fully operational. RYS will evaluate the system as the rainy season progresses and will take the results of these evaluations into consideration when making decisions on the permanent system.

The following statement is provided, as required by the CAO, "I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment." Should you have any questions regarding this report or the monitoring program, please contact Bryan Clarkson of our staff at 707.678.1492.

Thank you for your time and consideration

Sincerely,

Dave Vaughn
Vice President & Group General Manager

Attachment

cc: Paul Donoho, Yuba County Environmental Health Department
Andrew Altevogt, CVRWQCB
Kenneth Haskell, Golder Associates
Paul Yamamoto, Recology Environmental Solutions
Joe Matz, Recology Yuba-Sutter
Bryan Clarkson, Recology Environmental Solutions
Stephanie Kendall, Recology Yuba Sutter

WORK PLAN

COMPOST AREA LEACHATE COLLECTION WORK PLAN

Feather River Organics

Recology Yuba Sutter Facility

Submitted To: Recology Yuba Sutter
3001 North Levee Road
Marysville, CA 95901

Submitted By: Golder Associates Inc.
1000 Enterprise Way, Suite 190
Roseville, CA 95678 USA

January 2014

Project No. 1301525

A world of capabilities delivered locally

Golder Associates

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 INTRODUCTION

The Recology Yuba Sutter (RYS) facility located in Marysville, California (Figure 1) is comprised of existing closed landfill units, a Material Recycling Facility, an administration office, equipment maintenance area, and the Feather River Organics (FRO) composting facility. The FRO compost facility is located on Landfill 1 (LF-1), which was closed in the 1980's in accordance with the regulations in effect at the time. Prior to composting, FRO constructed a compost pad consisting of a 0.5-foot minimum low-permeability aggregate layer over the LF-1 final cover so that composting would not be conducted directly on the landfill cover.

The Central Valley Regional Water Quality Control Board (CVRWQCB) issued Cleanup and Abatement Order (CAO) R5-2013-0704 on August 29, 2013 requiring Recology to submit a Compost Area Leachate Collection Work Plan (Work Plan) which describes how contact stormwater generated in the compost and green waste areas will be managed. Golder has prepared this Compost Area Leachate Work Plan as a follow on to the Compost Area Work Plan (Golder, 2013a) to assist RYS in complying with the CAO and applicable state standards.

Order Item No. 9 of the CAO requires the following:

- A description of how leachate will be collected and directed to a containment and collection system, which is designed, constructed and operated, and maintained so that leachate is separated, to the extent possible from underlying closure cover of LF-1. Additional design requirements include:
  - The conveyance system shall be made of low-permeability materials
  - The drainage structures shall meet the standards of Section 20365 (a) and (c) of Title 27
- A description of the type of containment system in which leachate will be stored. Additional design requirements include:
  - Above ground tank or impoundment ponds with at least a single liner
  - Design specifications for the tanks and/or pond liner
  - Proposed monitoring of the unsaturated zone beneath the tanks or pond
  - Ponds shall not be constructed on top of a waste management unit (WMU) unless approved through amended Waste Discharge Requirements (WDR's)
  - Include a water balance to justify the size of tanks or pond
  - Minimum pond capacity shall meet specifications of Table 4.1 of Title 27
- Disposal of leachate in the containment system so that it has adequate storage at the beginning of each winter
- A construction schedule that will have the system installed and operational by October 1, 2014

To meet the requirements of CAO Order Item No. 9, Golder organized this Work Plan to include the following sections summarized below:

- CAO Order Item No. 9a:
  - A description of how FRO will manage the separation of leachate from the facility stormwater, including the low-permeability conveyance materials, is included in Section 2
  - The demonstration that the conveyance systems will be designed to comply with Section 20365 (a) and (c) of Title 27 is addressed in Section 3
- CAO Order Item No. 9b:
  - A description of the types of containment systems including design specifications is addressed in Section 4
  - A description of the proposed monitoring of the unsaturated zone beneath the tanks or pond is addressed in Section 4
  - The location of ponds (if constructed) is addressed in Section 2
  - A water balance model to justify the storage capacity in compliance with Table 4.1 of Title 27
- CAO Order Item No. 9c – Disposal of leachate in the containment system to ensure adequate storage capacity at the beginning of each winter is addressed in Section 4
- CAO Order Item No. 9d - A construction schedule is included in Section 5.1

Section 5.2 of this Work Plan also includes a discussion of alternatives to a large storage system that may be considered by RYS.

1.1 Existing Composting Facility Site Description

The current FRO permitted composting facility measures approximately 15.8 acres and is permitted by Yuba County to accept a maximum of 400 tons per day of green waste for processing with a capacity of 40,000 tons of material on-site at any one time. Materials are processed through an open windrow composting system. The composting operations take place on an existing compost pad measuring approximately 11.6 acres (Figure 2). The northern portion of the compost pad includes a low-permeability aggregate pad surface that FRO is currently amending to ensure a minimum 6-inch thick low-permeability aggregate surface layer. FRO intends to amend the existing aggregate surface over the remaining southern portion of the compost facility with a low-permeability aggregate as time and weather allows.

The northern portion of the compost area is bounded by the following features:

- A visual screening berm and landfill gas (LFG) horizontal header located adjacent to the pad on the northwest side
- A former soil borrow area located to the northeast, which is referred to as the "Hog Farm"
- Landfill No. 2 (LF-2) located to the southeast

The southern portion of the compost area is bounded by the following features:

- LF-2 to the northeast
- The truck maintenance area to the west
- A drainage swale to the south

Currently, the southern portion of the compost operation is used for storage of green waste and wood waste products. FRO plans to expand the composting operations in this area in the future.

1.2 Existing Compost Leachate Management

In October 2013, FRO began implementing a temporary stormwater management system to segregate surface water that comes into contact with the compost facility separately from the remaining facility surface water run-off.

LF-2, which is generally located to the west of the compost facility, contains a separate stormwater collection and conveyance system. Additionally, the truck maintenance and parking areas located south of the compost facility contain a separate stormwater collection and conveyance system with the exception of a small portion of stormwater that is conveyed towards the Hog Farm via the existing clay-lined drainage ditch on the north side of the compost area.

The northern portion of the compost pad includes a low-permeability aggregate surface layer which is designed to promote positive drainage and help impede infiltration. During the fall of 2013, a series of 6-inch diameter culverts spaced approximately every 100 feet were installed through the visual screening berm to facilitate drainage to the existing clay-lined drainage ditch.

FRO has recently implemented the following improvements to the compost pad:

- Constructed a small diversion berm at the northwest edge of the compost pad to direct surface water run-off through the 6-inch diameter culverts through the visual screening berm to the northern drainage ditch
- Installed a 24-inch diameter corrugated metal pipe (CMP) that discharges to an above-ground concrete storage vault at the eastern termination of the drainage ditch. Stormwater collected in the vault is pumped to two, approximately 21,000-gallon, above-ground metal storage tanks located at the northern end of the compost pad. Stormwater collected in these tanks is used for daily compost "make-up" water.
- Constructed a small diversion berm in the southern portion of compost pad area adjacent to the drainage swale. This berm will direct run-off to one of two newly constructed shallow sumps located at the southwest and southeast corners of the compost area. Each of these sumps includes a submersible pump with automated, water-level operational controls. The sumps convey water to an approximately 21,000-gallon, above ground, metal storage tank. Stormwater collected in this tank is used for daily compost make-up water.

Additionally, FRO is continuing to amend the existing compost pad with additional low-permeability aggregate to ensure that a minimum thickness of 6 inches is maintained during operations.

2.0 CONCEPTUAL COMPOST LEACHATE MANAGEMENT PLAN

As discussed in the Compost Pad Work Plan (Golder 2013a), the compost pad surface will be maintained to provide a minimum drainage grade of 3 percent. In addition, the surface of the compost pad will be maintained with a minimum 6-inch thick low-permeability aggregate surface layer to minimize infiltration into and to protect the underlying LF-1 final soil cover from the compost operations.

A permanent compost leachate management system will be installed to prevent discharge of compost leachate to the facility surface water management system. This compost leachate management system consists of the following features which are also illustrated in Figures 3 and 4:

- The 6-inch diameter culverts will be tied to an 18-inch diameter HDPE pipe placed within the existing northern clay-lined ditch to separate compost leachate from stormwater run-off from the area southwest of the compost pad.
- The temporary stormwater improvements for the southern portion of the compost area as described in Section 1.2 will be maintained.
- Compost leachate from the compost pad will be directed to a storage facility located in the Hog Farm. As discussed in Section 4, the storage facility will likely consist of a geomembrane-lined impoundment.
- Stormwater run-off from the southern portion of the compost area will be managed as compost leachate and will be either stored in an existing 21,000 gallon storage tank or pumped from the storage tank to the proposed lined impoundment. Alternatively, FRO may pump the stormwater run-off from this area directly to the impoundment or to the sanitary sewer.
- If necessary to provide adequate storage capacity, excess liquids in the storage facility will be pumped to the sanitary sewer for disposal prior to each winter.

3.0 COMPOST LEACHATE AND STORMWATER VOLUME CALCULATIONS

Order No. 9 of the CAO requires that the compost leachate storage system be sized for a minimum 100-Year (Yr), 24-hour (Hr) storm event. In addition, Section 9 of the CAO requires water balance modeling to ensure that the storage system has sufficient capacity to store compost leachate through the winter.

To determine the required capacities for the conceptual compost leachate management system described in Section 2, Golder modeled peak flows for a 100-Yr, 24-Hr storm event. Peak flow calculations are discussed in Section 3.1. To estimate the quantity of liquids storage and/or disposal required annually, Golder modeled annual precipitation totals using historical precipitation data from the Western Regional Climate Center (WRCC) to estimate stormwater quantities for average annual conditions and for a 100-Yr annual return period. This WRCC data used in Golder's calculations was obtained from a nearby weather data collection station located in the town of Marysville, California approximately 2.5 miles from the RYS facility (WRCC, 2013). Annual precipitation totals are discussed in Section 3.2. Annual and daily leachate disposal quantities and rates are discussed in Section 3.3.

3.1 Peak Stormwater Run-off and Compost Leachate Modeling

To estimate peak stormwater run-off and compost leachate for a 100-Yr, 24-Hr storm event, Golder evaluated surface water controls at the site using the 2013 Storm and Sanitary Analysis (SSA) program developed by Autodesk®. SSA is hydrological model that contains a set of hydraulic modeling capabilities used to model precipitation and stormwater run-off through a drainage system network of pipes, channels, storage/treatment units, and diversion structures. Specific key model parameter inputs and assumptions include:

- Golder used EPA's Storm Water Management Model (SWMM) method within the SSA program to model precipitation and stormwater run-off.
- Golder assumed 40 percent of the compost area is covered with compost piles and that these piles initially absorb precipitation. Therefore, the runoff curve number for the compost pad area was assumed to be 52.6 which represents a weighted average consisting of little run-off from the compost piles and the uncovered portion of the compost pad surface which is comprised of a compacted, low-permeability aggregate.
- The compost pad will be graded to a minimum uniform three (3) percent to provide constant positive drainage.
- A 24-Hr SCS Type I storm distribution was used for the model with a total precipitation depth of 5.76 inches for the 100-Yr, 24-Hr design storm event.
- An 18-inch diameter pipe would be installed in the existing stormwater collection ditch located adjacent to the northern portion of the compost pad. This pipe would be connected to each of the 6-inch diameter culverts that direct flow from the compost pad towards the Hog Farm area.

The SSA peak run-off calculations output is presented in Appendix A.

These calculations indicate the following:

- The peak compost leachate discharge from the northern area of the compost pad is estimated to be 6.2 cfs. The proposed 6-inch diameter culverts through the screening berm and 18-inch diameter collection pipe have sufficient capacity to convey this peak discharge.
- The northern ditch has sufficient capacity to convey stormwater from the area southwest of the compost pad while also containing the 18-inch diameter pipe.
- The peak compost leachate discharge from the southern area of the compost pad is estimated to be 6.2 cfs. The proposed pipes and pumps that convey water to the 21,000 gallon storage tank have sufficient capacity to convey this peak discharge.
- The total run-off from the northern and southern portions of the compost pad is estimated to be 6.1-acre feet for the 100-Yr, 24-Hr storm event.

3.2 Preliminary Water Balance and Compost Leachate Storage

It is Golder's experience that the capacity of leachate storage systems is controlled by the balance of the inflows and outflows throughout the winter and not by a single, large precipitation event (i.e. 100-Yr, 24-Hr storm). Therefore, Golder completed a preliminary water balance analysis to estimate the size of the storage facility. The water balance calculations are preliminary in that they model monthly stormwater/leachate inflows and monthly outflows of compost make-up water. Evaporative losses were estimated using an assumed constant surface water area, which will change with water level changes if impoundments are used. Accordingly, more detailed water balance calculations will be completed as part of the final design of the impoundment.

To estimate the preliminary size of the storage facility, Golder used the following design criteria:

- The inflows must be equal to or less than the outflows for average conditions
- The storage facility must be able to accommodate a 100-year wet year
- The storage facility should have a minimum 2-foot freeboard above the maximum predicted water level

Data obtained from the WRCC was used to estimate total average precipitation expected at the site which measures approximately 21 inches per year (WRCC, 2013). To conservatively estimate additional precipitation expected due to an annual 100-Yr return period, Golder obtained the historical precipitation depths from the California Department of Water Resources (CA DWR, 2013) which indicates that the total precipitation depth for an annual 100-Yr return period measures approximately 37 inches. Monthly totals for a 100-Yr return period were not available; therefore, Golder estimated monthly precipitation depths for a 100-Yr return period by multiplying the average monthly precipitation depths by the percentage difference between the average annual total depth and the

100-Yr total return period depth (Scale factor). Table 1 includes average and scaled monthly and annual precipitation values for the site.

Table 1: Precipitation Depths

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Total Precipitation (in.)	4.01	3.73	2.88	1.53	0.75	0.22	0.03	0.06	0.34	1.21	2.44	3.76	21.0
Scaled Total Precipitation (in.)	7.11	6.61	5.11	2.71	1.33	0.39	0.05	0.11	0.60	2.15	4.33	6.67	37.2

Note:
1. Values obtained by multiplying the average depths for each month by a scale factor of 1.77

FRO uses approximately 15,000 gallons per day for compost make-up water. For the water balance, Golder assumed that the site operates an average of six days per week which equates to approximately 360,000 to 405,000 gallons used per month. Evaporative losses were estimated by using an assumed water surface area for an impoundment, which was multiplied by the average monthly evaporation rate estimated for Folsom Lake Dam (WRCC, 2014) located approximately 38 miles south-southeast of the facility. Figure 5 illustrates the cumulative totals for average annual conditions and a 100-Yr return period storm for a 4.3 acre basin. The preliminary water balance calculations are summarized in Appendix A. Options considered for the storage and/or disposal of leachate include the following:

- Option 1 - Temporary storage in above ground tanks and then disposal of leachate to the sanitary sewer
- Option 2 – Permanent storage in above ground tanks and disposal of excess leachate to the sanitary sewer if required
- Option 3 – Permanent storage in an impoundment and disposal of excess leachate to the sanitary sewer if required

For Option 1, Golder evaluated peak and long-term compost leachate disposal quantities Table 2 summarizes average and peak monthly and annual totals

Table 2: Compost Leachate Disposal Quantities

Annual Storm Conditions	Annual Leachate Disposal		Peak Monthly Leachate Disposal	
	Total Volume (Gal.)	Daily Disposal Rate (gal/day)[1]	Peak Monthly Volume (gallons/month)	Average Disposal Rate for Peak Monthly Volume (Gal/day)[2]
Average Conditions	1,850,000	5,800	1,260,000	47,000
100-Yr Return Period	6,960,000	22,000	2,240,000	83,000

Notes:
1. Based on 6 days per week totaling 317 days per year
2. Based on 27 working days per month

Peak daily disposal quantities from Table 2 would require estimated average disposal rates measuring 97 gallons per minute (gpm) for average conditions and 173 gpm for a 100-Yr return period. These would require considerably larger pumps than have been specified for the temporary compost leachate management system.

For Option 2, we estimate that approximately 332 21,000-gallon storage tanks would be required unless a significant portion of the compost leachate was discharged to the sanitary. Therefore, if FRO desires to manage the liquids primarily through storage, Golder recommends constructing a lined impoundment in the Hog Farm (Option 3).

Using the design criteria previously discussed, a lined impoundment needs a minimum storage capacity of 33.6 acre-feet assuming that leachate is not discharged to the sanitary sewer during winter months. Assuming an 11-foot deep impoundment (including 2 feet of freeboard), Golder estimates that the impoundment will measure approximately 4.3-acres in size. Allowing for the use of the leachate as compost make-up water and for evaporative losses, Golder anticipates that the impoundment will contain sufficient capacity following a 100-yr return period to contain the total run-off volume for a typical average annual rainfall season. During above-average precipitation conditions, there may be excess liquids that would need to be disposed of to the sanitary sewer.

4.0 DESIGN SPECIFICATIONS FOR COMPOST LEACHATE STORAGE FACILITIES

Design specifications for the compost leachate storage facilities are summarized as follows:

- Stormwater from the southern portions of the compost operations area will be either pumped directly into the impoundment or may be temporarily stored into a 21,000 gallon, above ground, metal storage tank such as those manufactured by the Baker Tank Company. If the above ground tank is used, it will be located on the low-permeability aggregate surface of the compost operations. In addition, water will be transferred to an impoundment if water reaches within 2 feet of the top of the tank. This tank will require a single vacuum lysimeter located within the upper 2 feet of the soil subgrade. The location and installation details for the lysimeter will be prepared with final design plans for the impoundment.
- The impoundment will be located in the Hog Farm and constructed primarily with fill soils to form the sides while maintaining the bottom elevation at or within 4 feet or the existing ground surface. Fill soils will be compacted to a minimum relative compaction of 90 percent per ASTM D 1557. The side slopes of the impoundment will be inclined at 2H:1V or less.
- A lined impoundment will be sized to accommodate leachate and storage volumes discussed in Section 3.2 with a minimum of 2 feet of freeboard. A final water balance analysis will be completed for the impoundment that will include monthly accounting for inflows and outflows based on monthly computed water levels within the proposed impoundment grades. Figure 3 shows the estimated footprint and location of the impoundment within the Hog Farm.
- The 100-year flood elevation will be reviewed, and if necessary, one or more sides of the impoundment will be raised to a minimum of 2 feet above the 100-year flood elevation to protect it from inundation from the design flood event.
- Due to the presence of shallow groundwater (i.e. within 10 to 15 feet of the anticipated maximum groundwater elevations) and a relatively permeable natural subgrade consisting of a silty sand, the impoundment will be lined with a geomembrane/low-permeability material composite liner to minimize the leakage potential. Specifications for the composite liner include the following:
  - The geomembrane shall consist of minimum 60-mil high-density polyethylene (HDPE) geomembrane meeting the requirements of GRI-GM-13. Appendix B includes preliminary material and installation specifications for the geomembrane.
  - The low-permeability material will consist of either a geosynthetic clay liner (GCL) such as Bentomat DN or equivalent or a minimum 1-foot thick low-permeability soil with a permeability of 1×10^{-6} cm/s or less. Preliminary material and installation specifications for a GCL are included in Appendix B. If a low-permeability soil is used, the material and construction specifications will be prepared as part of the final design.
  - Construction of the pond and liner will be completed in accordance with construction plans, technical specifications, and construction quality assurance plan that will be prepared as part of the final design.
  - A geoelectric leak location survey will be completed on the upper geomembrane surface following installation and prior to operation. The geoelectric leak location survey will be completed in accordance with ASTM D 7002. All defects located by leak survey will be repaired prior to operation of the impoundment.

- Prior to each winter, the liquids in the pond need to be removed to a depth of no more than 6 inches by October 1st of each year. Some minor amount of liquids is beneficial in providing ballast against wind uplift.

Unsaturated zone monitoring will be completed by installing two vacuum lysimeters in the subgrade beneath the base of the impoundment. The lysimeters will be installed within the upper 2 feet of the soil subgrade. The location and installation details for the lysimeters will be prepared with final design plans for the impoundment.

If a storage tank is used, a single vacuum lysimeter or secondary containment structure will be installed directly below the tank. FRO will evaluate which option to choose and will implement either a lysimeter or secondary containment during the design and construction of the permanent storage structure. The tank will need to set on a level surface, and therefore, it anticipated that the low-permeability aggregate will be constructed at a thickness of 9 to 12-inches, which should be adequate to support the lysimeter. Preliminary technical specifications for vacuum lysimeters are included in Appendix B. If a secondary containment structure is constructed, it will be sized based on the Environmental Protection Agency's (EPA's) secondary containment guidelines for above ground tanks.

5.0 FINAL DESIGN, PERMITTING, AND CONSTRUCTION SCHEDULE

5.1 On-site Storage of Compost Leachate

On-site storage of compost leachate is a potential technical solution capable of managing the leachate so that it is not comingled with storm water runoff. Due to the topography of the site and proximity to the levee, the only feasible location for a proposed impoundment is to place it within the Hog Farm. However, the Hog Farm is currently not part of the permitted FRO facility and therefore does not fall with the FRO use permit. RYS anticipates that it will need additional time to prepare documents for the permitting effort, which at a minimum will require a mitigated negative declaration (MND) and may require a full environmental impact report (EIR). Due to the permitting effort required, RYS is proposing the following schedule which does not meet the timelines set forth in the CAO. RYS intends to keep the temporary stormwater collection system recently installed in place. Recology will finalize the design of the leachate collection, storage, and management system following permitting approval and RWQCB review and approval of this Work Plan. Accordingly, the design, permitting, and construction schedule is as follows:

- Submittal of this Work Plan: January 31, 2014
- RWQCB review and approval of the Work Plan March 17, 2014
- Prepare preliminary feasibility design report for permitting May 30, 2014
- Permitting through other regulatory agencies January 2, 2015
- Prepare and submit preliminary final design report, construction plans, technical specifications, and CQA Plan March 27, 2015
- RWQCB review and approval of the design documents June 1, 2015
- Construction bidding and contractor selection July 17, 2015
- Complete construction of the leachate collection and storage system October 1, 2015

5.2 Alternatives to On-site Storage of Compost Leachate

Recology may consider one or more of the following alternatives in lieu of constructing an on-site impoundment:

- Close the compost facility and move the operations offsite
- Close the compost facility and direct green waste feedstock and food waste to a landfill for use as an alternative daily cover
- Evaluate the use of on-site bioswales or bioremediation systems to treat the compost leachate prior to offsite discharge
- Evaluate other treatment systems for treating leachate prior to offsite discharge
- Additional options may be evaluated

All of the above alternatives, with the exception of directing green waste feedstock and food waste to a landfill, will require environmental review, completion of California Environmental Quality Act studies, land use approvals, and other permits such as a NPDES permit for options that include off-site discharge of treated compost leachate. This permitting would likely extend beyond the current completion date stipulated in the CAO.

6.0 CLOSING

This Work Plan fulfills the submittal requirement for RYS stated in the CAO Compliance Order No. 9. Please call one of the undersigned at (916) 786-2424 if you have any questions or require additional information.

Sincerely,

GOLDER ASSOCIATES INC.

Joel Kelsey
Project Engineer

Ken Haskell, P.E.
Principal

REGISTERED PROFESSIONAL ENGINEER
KENNETH G. HASKELL
No. C053290
Exp. 6/30/15
CIVIL
STATE OF CALIFORNIA

7.0 REFERENCES

Central Valley Regional Water Quality Control Board (CVRWQCB), "Cleanup and Abatement Order R5-2013-0704, Recology Yuba Sutter Landfill, Yuba County", August 29, 2013.

Golder Associates, Inc. (Golder, 2013a) "Compost Area Work Plan, Feather River Organics, Recology Yuba Sutter Facility" Dated October, 2013.

Golder Associates, Inc. (Golder, 2013b) "Conceptual Design of Temporary Stormwater Collection and Management System for Feather River Organics Composting Operation, Recology Yuba Sutter Facility, Marysville, California" Dated November 15, 2013.

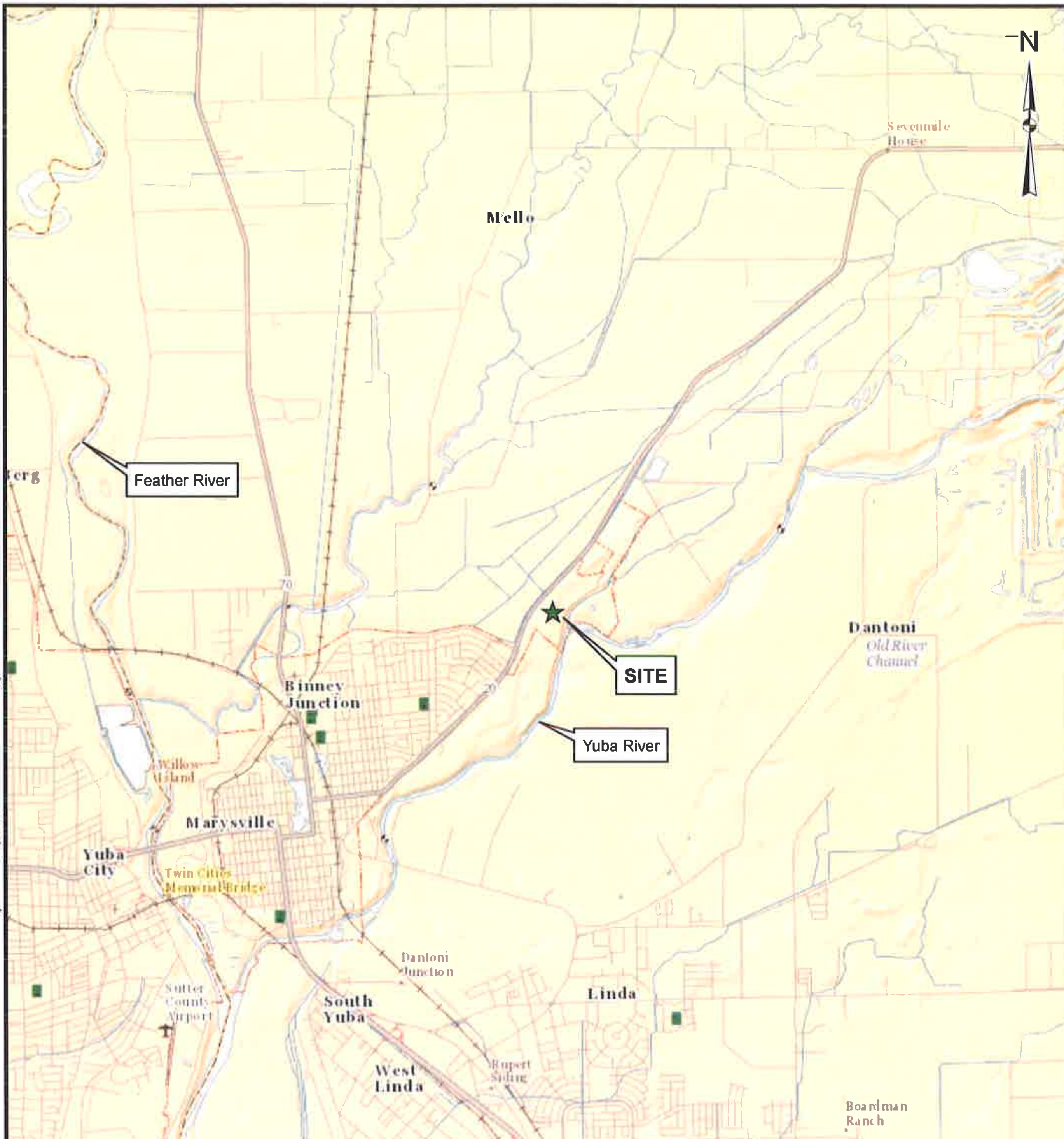
Golder Associates, Inc. (Golder, 2013c) "Compost Pad Operations and Maintenance Manual" Dated October 28, 2013.

Western Regional Climate Center (WRCC, 2013) Period of Record Monthly Climate Summary for Marysville, California (045385), Accessed October 20, 2013

California Department of Water Resources (CA DWR, 2013), Rainfall Depth Duration Frequency for Station No. A00 5385, ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall%20Dept-Duration-Frequency/, Accessed December 26, 2013.

Western Regional Climate Center (WRCC, 2014) California Monthly Average Pan Evaporation (Inches) for Folsom Dam, Folsom, California, http://www.wrcc.dri.edu/htmlfiles/westevap.final.html, Accessed January 19, 2014

FIGURES



LEGEND

★ Site Location

NOTES

1. Topographic map obtained from the USGS National Map web service (http://www.nationalmap.gov), based on latest USGS 7.5 minute quadrangle format. Source: USGS, TomTom, U.S. Census Bureau.

REFERENCES

1. Coordinate system: NAD 1983 StatePlane California II FIPS 0402 Feet

PROJECT RECOLOGY YUBA-SUTTER (YSDI)
COMPOST AREA LEACHATE COLLECTION WORK PLAN
YUBA COUNTY, CA

TITLE
SITE LOCATION MAP

Golder Associates

PROJECT NO 1301525			FILE No. 1301525-F1-SITELOC1.mxd	
DESIGN	JDR	6 Dec 2013	SCALE AS SHOWN	REV. 0
GIS	JDR	30 Jan 2014	FIGURE 1	
CHECK	JTK	30 Jan 2014		
REVIEW	KGH	30 Jan 2014		

Map Document: M:\Sites\YSDI LF\GIS\1301525\1301525-F1-SITELOC1.mxd / Modified 1/30/2014 4:21:57 PM by JRaub / Exported 1/30/2014 4:22:12 PM by JRaub

LEGEND

- Approximate Limit of LF-1
- Permitted FRO Compost Operations
- Screening Berm

NOTES

1. Aerial imagery obtained from ESRI Basemap web service titled World_Imagery. Date of imagery: Feb. 2, 2012. Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

REFERENCES

1. Coordinate system: NAD 1983 StatePlane California II FIPS 0402 Feet

200 0 200
Feet

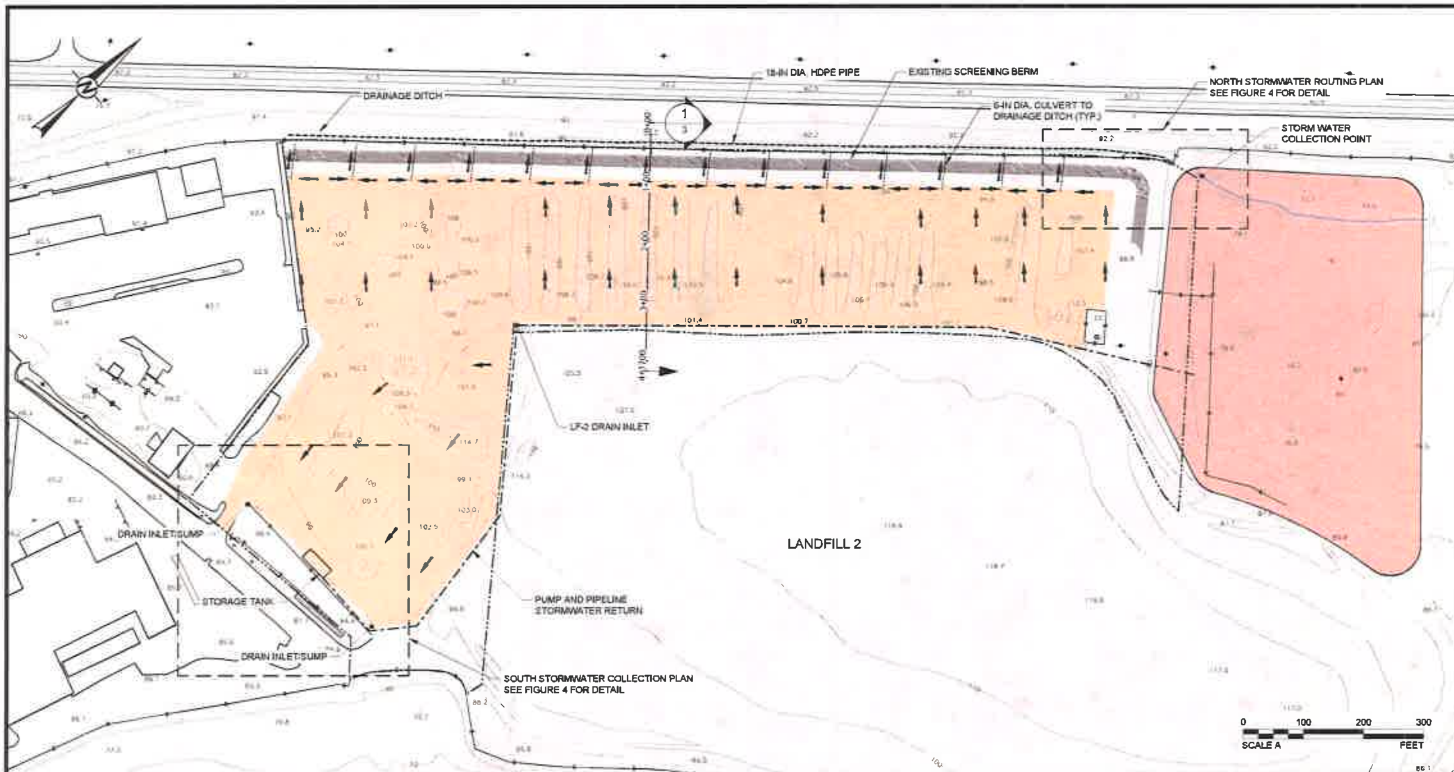
PROJECT
RECOLOGY YUBA-SUTTER (YSDI)
COMPOST AREA LEACHATE COLLECTION WORK PLAN
YUBA COUNTY, CA

TITLE
SITE PLAN

Golder Associates

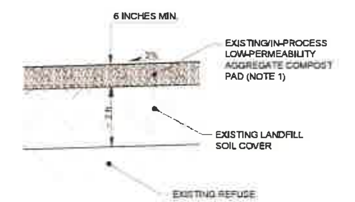
FIGURE 2

Map Document: M:\Sites\YSDI LF\GIS\1301525\1301525-F2-SITEPLAN2.mxd / Modified 1/17/2014 11:52:10 AM by JRaab / Exported 1/17/2014 11:52:35 AM by JRaab



LEGEND

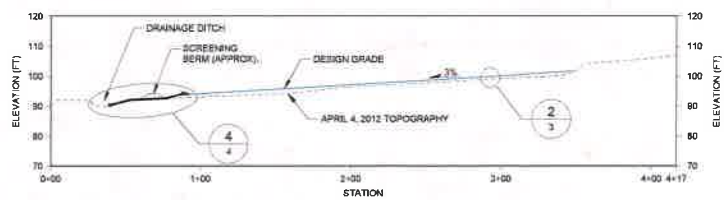
- COMPOST FACILITY
- PRELIMINARY STORAGE IMPOUNDMENT AREA
- PERMITTED BOUNDARY OF COMPOST FACILITY
- STORMWATER RETURN PIPELINE
- 18-IN DIA. HDPE PIPE
- 6-IN DIA. CULVERT
- SURFACE WATER FLOW DIRECTION



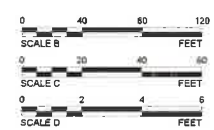
SCALE D (2/3) TYPICAL COMPOST SECTION

SPECIFICATIONS

1. COMPOST PAD SHALL CONSIST OF A 1.5-INCH MINUS CLASS 2 OR CLASS 3 AGGREGATE BASE WITH A MINIMUM OF 15 PERCENT FINES CONTENT IN ACCORDANCE WITH CALTRANS STANDARD SPECIFICATIONS.
2. THE AGGREGATE BASE SHALL BE COMPACTED TO A MINIMUM 90 PERCENT RELATIVE COMPACTION AT A MOISTURE CONTENT 1 TO 4 PERCENT ABOVE OPTIMUM WATER CONTENT (ASTM D 1557).



HORI. SCALE B / VERT. SCALE C (1/3) SECTION A



NOTES

3. TOPOGRAPHIC INFORMATION PREPARED USING PHOTOGRAMMETRIC METHODS BY AERIAL DATA INC. DATE OF TOPOGRAPHY: APRIL 4, 2012.

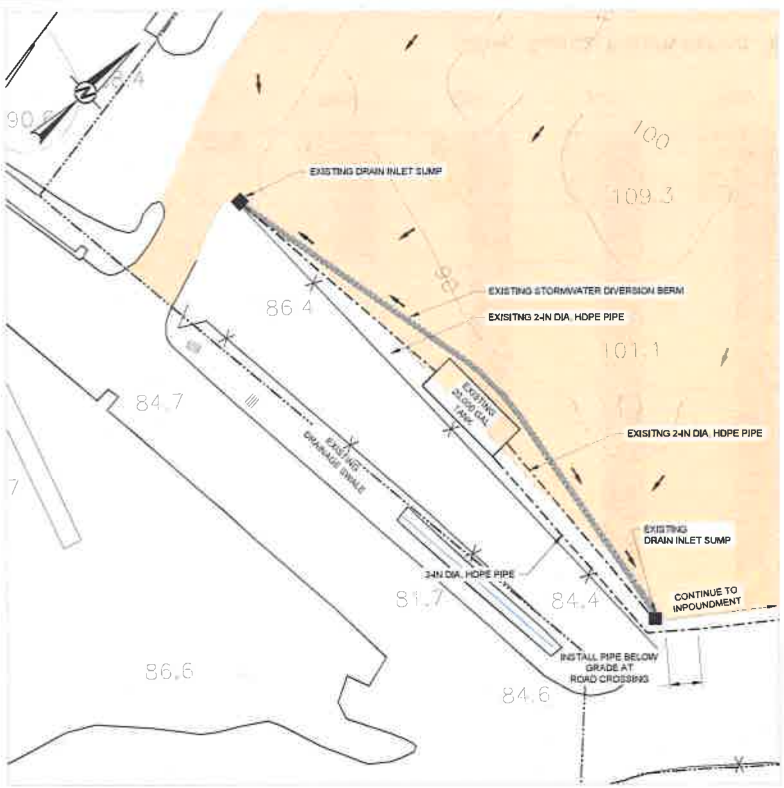
PROJECT
RECOLOGY YUBA-SUTTER (YSDI)
COMPOST AREA LEACHATE COLLECTION WORK PLAN
YUBA COUNTY, CA

TITLE
CONCEPTUAL STORMWATER IMPROVEMENTS PLAN

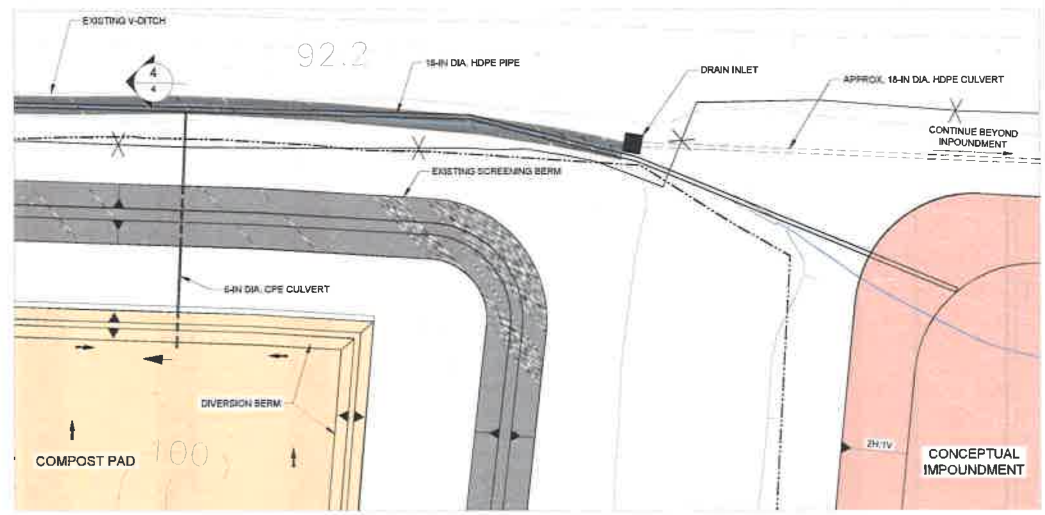
Golder Associates

PROJECT No.		130-1525	FILE No.	RYS CAD BASINS_R1
DESIGN	JTK	16 JAN 2014	SCALE	AS SHOWN
CADD	JDR	16 JAN 2014		
CHECK	JTK	16 JAN 2014		
REVIEW	RGH	16 JAN 2014		

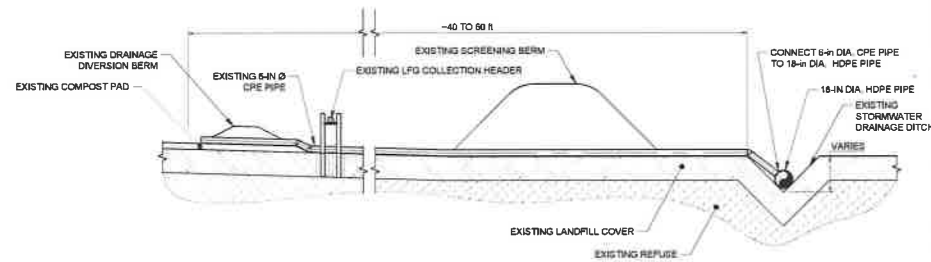
FIGURE 3



SOUTH STORMWATER COLLECTION PLAN
SCALE A



NORTH STORMWATER ROUTING PLAN
SCALE B



NOT TO SCALE (4/4) 6-IN DIA. PVC DRAIN PIPE

LEGEND

- COMPOST FACILITY
- 100-YEAR, 24-HOUR EVENT BASIN
- 100-YEAR RETURN PERIOD BASIN
- PERMITTED BOUNDARY OF COMPOST FACILITY
- STORMWATER RETURN PIPELINE
- SURFACE WATER FLOW DIRECTION

SCALE A: 0 30 60 90 FEET
SCALE B: 0 20 40 60 FEET

NOTES

1. TOPOGRAPHIC INFORMATION PREPARED USING PHOTOGRAMMETRIC METHODS BY AERIAL DATA INC. DATE OF TOPOGRAPHY: APRIL 4, 2012.

PROJECT
RECOLOGY YUBA-SUTTER (YSDI)
COMPOST AREA LEACHATE COLLECTION WORK PLAN
YUBA COUNTY, CA

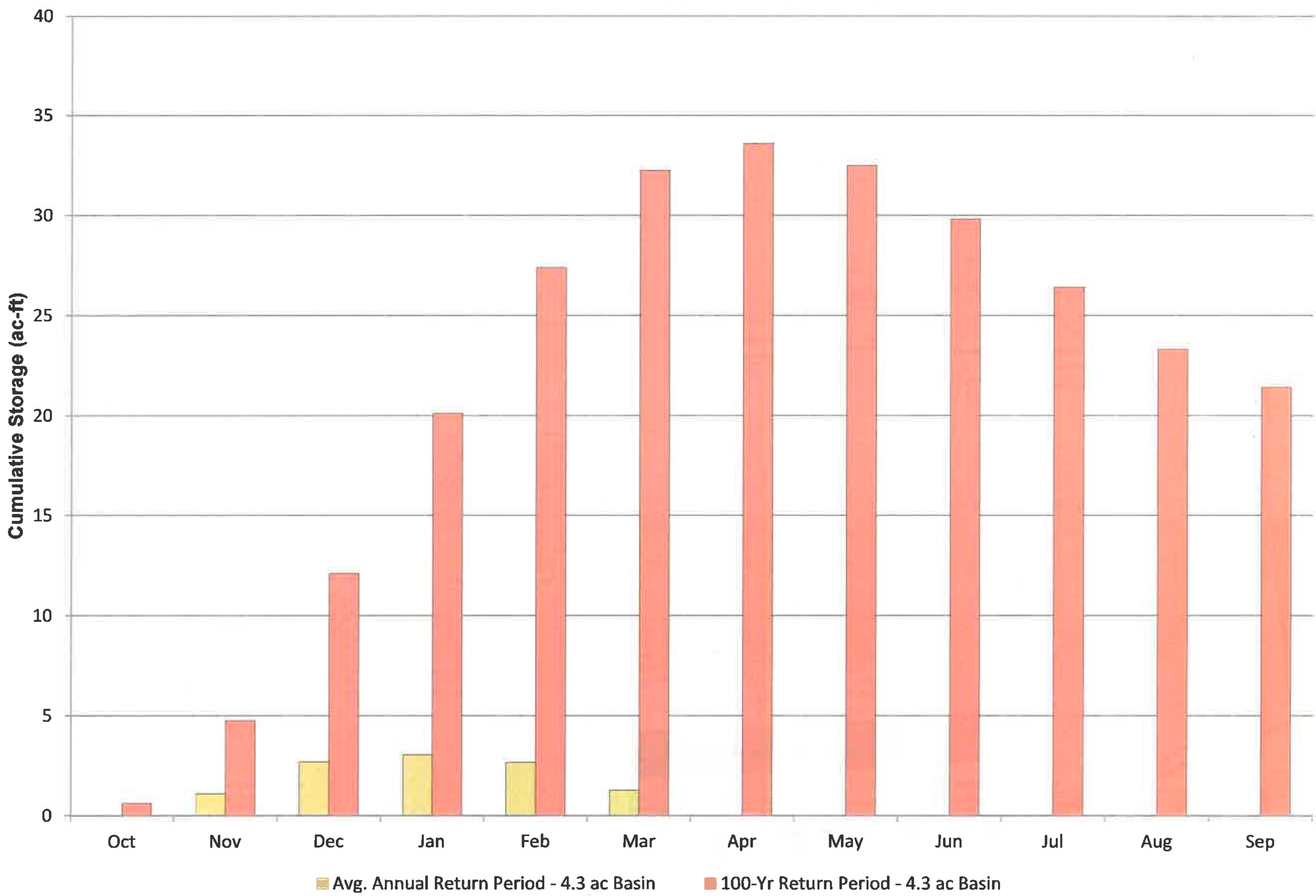
TITLE
CONCEPTUAL STORMWATER IMPROVEMENTS DETAILS

Golder Associates

PROJECT No.		130-1525	FILE No.	RYS CAD BASINS_R2
DESIGN	JTK	16 JAN 2014	SCALE	AS SHOWN
CADD	JDR	16 JAN 2014		
CHECK	JTK	16 JAN 2014		
REVIEW	KGH	16 JAN 2014		

FIGURE 4

Figure 5: Cumulative Stormwater Volumes



APPENDIX A
STORMWATER AND COMPOST LEACHATE CALCULATIONS

Autodesk® Storm and Sanitary Analysis 2013 - Version 7.1.2186 (Build 1)

****
Project Description
****

File Name .... RYS FRO 100 YR DESIGN_r1.SPF

****
Analysis Options
****

Flow Units .... cfs
Subbasin Hydrograph Method. EPA SWMM
Infiltration Method .... SCS Curve Number
Link Routing Method .... Kinematic Wave
Storage Node Exfiltration.. None
Starting Date OCT-20-2013 00:00:00
Ending Date OCT-25-2013 00:00:00
Antecedent Dry Days 0.0
Report Time Step 00:05:00
Wet Time Step 00:05:00
Dry Time Step 01:00:00
Routing Time Step .... 30.00 sec

****
Element Count
****

Number of rain gages 1
Number of subbasins 5
Number of nodes 9
Number of links 8
Number of pollutants 0
Number of land uses 0

****
Raingage Summary
****

Gage ID	Data Source	Data Type	Recording Interval min
Rain Gage-01	100-YR,24-HR	CUMULATIVE	6.00

****
Subbasin Summary
****

Subbasin ID	Total Area ft²	Equiv. Width ft	Imperv. Area %	Average Slope %	Raingage
Sub-01	118782.81	311.60	0.00	3.0000	Rain Gage-01
Sub-02	91518.54	308.48	0.00	3.0000	Rain Gage-01
Sub-03	102040.33	321.23	0.00	3.0000	Rain Gage-01
Sub-04	97639.13	500.00	0.00	3.0000	Rain Gage-01
Sub-06	68700.99	500.00	0.00	3.0000	Rain Gage-01

****
Node Summary
****

Node ID	Element Type	Invert Elevation ft	Maximum Elev. ft	Ponded Area ft²	External Inflow
Jun-01	JUNCTION	92.00	94.00	0.00	
Jun-02	JUNCTION	91.00	93.00	0.00	
Jun-03	JUNCTION	89.00	91.00	0.00	
Jun-SouthTank	JUNCTION	86.00	88.00	0.00	
Out-01	OUTFALL	78.00	86.00	0.00	
Pond	STORAGE	80.00	88.00	0.00	
S_Baker	STORAGE	86.00	94.00	0.00	
SE_Sump	STORAGE	80.00	86.00	0.00	
SW_Sump	STORAGE	80.00	86.00	0.00	

****
Link Summary
****

Link ID	From Node	To Node	Element Type	Length ft	Slope %	Manning's Roughness
3-in_Return	Jun-SouthTank	Pond	CONDUIT	1678.7	0.3574	0.0150
Link-04	Jun-01	Jun-02	CONDUIT	446.1	0.2242	0.0150
Link-05	Jun-02	Jun-03	CONDUIT	395.3	0.5060	0.0150
Link-09	Jun-03	Pond	CONDUIT	801.2	1.1233	0.0150
S_Bkr_Pond	S_Baker	Jun-SouthTank	TYPE2 PUMP			
SE_Sump_Pump	SE_Sump	S_Baker	TYPE3 PUMP			
SW_Sump_Pump	SW_Sump	S_Baker	TYPE3 PUMP			
Weir-01	Pond	Out-01	WEIR			

****
Cross Section Summary
****

Link ID	Shape	Depth/ Diameter ft	Width ft	No. of Barrels	Cross Sectional Area ft²	Full Flow Hydraulic Radius ft	Design Flow Capacity cfs
3-in_Return	CIRCULAR	0.25	0.25	1	0.05	0.06	0.05
Link-04	CIRCULAR	1.50	1.50	1	1.77	0.38	4.31
Link-05	CIRCULAR	1.50	1.50	1	1.77	0.38	6.48
Link-09	CIRCULAR	1.50	1.50	1	1.77	0.38	9.65

****
Runoff Quantity Continuity
****

	Volume acre-ft	Depth inches
Total Precipitation	5.275	5.760
Evaporation Loss	0.000	0.000
Infiltration Loss	3.404	3.717
Surface Runoff	1.841	2.010
Final Surface Storage	0.030	0.033
Continuity Error (%)	-0.006	

****
Flow Routing Continuity
****

	Volume acre-ft	Volume Mgallons
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	1.842	0.600
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.000	0.000
Surface Flooding	0.564	0.184

Evaporation Loss	0.000	0.000
Initial Stored Volume	0.467	0.152
Final Stored Volume	1.764	0.575
Continuity Error (%) ..	-0.824	

****
Composite Curve Number Computations Report
****

Subbasin Sub-01

Soil/Surface Description	Area (ft²)	Soil Group	CN
COMPACT_CLAYEY-LOAM_SOIL(ACCESS_ROAD)	71269.67	-	87.00
COMPOST_PILE	47513.14	-	1.00
Composite Area & Weighted CN	118782.81		52.60

Subbasin Sub-02

Soil/Surface Description	Area (ft²)	Soil Group	CN
COMPACT_CLAYEY-LOAM_SOIL(ACCESS_ROAD)	54911.12	-	87.00
-	36607.41	-	1.00
Composite Area & Weighted CN	91518.54		52.60

Subbasin Sub-03

Soil/Surface Description	Area (ft²)	Soil Group	CN
COMPACT_CLAYEY-LOAM_SOIL(ACCESS_ROAD)	61224.20	-	87.00
-	40816.12	-	1.00
Composite Area & Weighted CN	102040.33		52.60

Subbasin Sub-04

Soil/Surface Description	Area (ft²)	Soil Group	CN
Dirt roads	58583.48	C	87.00
-	39055.65	-	1.00
Composite Area & Weighted CN	97639.13		52.60

Subbasin Sub-06

Soil/Surface Description	Area (ft²)	Soil Group	CN
Dirt roads	41220.57	C	87.00
-	27480.41	-	1.00
Composite Area & Weighted CN	68700.99		52.60

****
EPA SWMM Time of Concentration Computations Report
****

Tc = (0.94 * (L^0.6) * (n^0.6)) / ((i^0.4) * (S^0.3))

Where:

Tc = Time of Concentration (min)

L = Flow Length (ft)
n = Manning's Roughness
i = Rainfall Intensity (in/hr)
S = Slope (ft/ft)

Subbasin Sub-01

Flow length (ft):	381.22
Pervious Manning's Roughness:	0.10000
Impervious Manning's Roughness:	0.01500
Pervious Rainfall Intensity (in/hr):	0.24000
Impervious Rainfall Intensity (in/hr):	0.24000
Slope (%):	3.00000
Computed TOC (minutes):	42.34

Subbasin Sub-02

Flow length (ft):	296.69
Pervious Manning's Roughness:	0.10000
Impervious Manning's Roughness:	0.01500
Pervious Rainfall Intensity (in/hr):	0.24000
Impervious Rainfall Intensity (in/hr):	0.24000
Slope (%):	3.00000
Computed TOC (minutes):	36.43

Subbasin Sub-03

Flow length (ft):	317.67
Pervious Manning's Roughness:	0.10000
Impervious Manning's Roughness:	0.01500
Pervious Rainfall Intensity (in/hr):	0.24000
Impervious Rainfall Intensity (in/hr):	0.24000
Slope (%):	3.00000
Computed TOC (minutes):	37.95

Subbasin Sub-04

Flow length (ft):	195.29
Pervious Manning's Roughness:	0.10000
Impervious Manning's Roughness:	0.01500
Pervious Rainfall Intensity (in/hr):	0.24000
Impervious Rainfall Intensity (in/hr):	0.24000
Slope (%):	3.00000
Computed TOC (minutes):	28.34

Subbasin Sub-06

Flow length (ft):	137.41
Pervious Manning's Roughness:	0.10000
Impervious Manning's Roughness:	0.01500
Pervious Rainfall Intensity (in/hr):	0.24000
Impervious Rainfall Intensity (in/hr):	0.24000
Slope (%):	3.00000
Computed TOC (minutes):	22.95

Subbasin Runoff Summary

Subbasin ID	Total Rainfall in	Total Runon in	Total Evap. in	Total Infil. in	Total Runoff in	Peak Runoff cfs	Runoff Coefficient	Time of Concentration days hh:mm:ss
Sub-01	5.76	0.00	0.00	3.73	2.00	2.32	0.348	0 00:42:20
Sub-02	5.76	0.00	0.00	3.73	2.01	2.00	0.349	0 00:36:25
Sub-03	5.76	0.00	0.00	3.73	2.01	2.17	0.348	0 00:37:57
Sub-04	5.76	0.00	0.00	3.70	2.02	2.46	0.350	0 00:28:20
Sub-06	5.76	0.00	0.00	3.70	2.02	1.88	0.351	0 00:22:57

Node Depth Summary

Node ID	Average Depth Attained ft	Maximum Depth Attained ft	Maximum HGL Attained ft	Time of Max Occurrence days hh:mm	Total Flooded Volume acre-in	Total Time Flooded minutes	Retention Time hh:mm:ss
Jun-01	0.03	0.75	92.75	0 10:06	0	0	0:00:00
Jun-02	0.04	0.86	91.86	0 10:07	0	0	0:00:00
Jun-03	0.04	0.88	89.88	0 10:07	0	0	0:00:00
Jun-SouthTank	0.44	2.00	88.00	0 09:58	0.01	1570	0:00:00
Out-01	0.00	0.00	78.00	0 00:00	0	0	0:00:00
Pond	0.34	0.38	80.38	2 23:50	0	0	0:00:00
S_Baker	1.39	8.00	94.00	0 10:17	6.71	862	0:00:00
SE_Sump	0.10	6.00	86.00	0 10:05	0.04	8	0:00:00
SW_Sump	0.31	6.00	86.00	0 10:01	0.01	3	0:00:00

Node Flow Summary

Node ID	Element Type	Maximum Lateral Inflow cfs	Peak Inflow cfs	Time of Peak Inflow Occurrence days hh:mm	Maximum Flooding Overflow cfs	Time of Peak Flooding Occurrence days hh:mm
Jun-01	JUNCTION	2.17	2.17	0 10:06	0.00	
Jun-02	JUNCTION	2.00	4.02	0 10:07	0.00	
Jun-03	JUNCTION	2.32	6.21	0 10:07	0.00	
Jun-SouthTank	JUNCTION	0.00	0.05	0 09:58	0.00	0 09:58
Out-01	OUTFALL	0.00	0.00	0 00:00	0.00	
Pond	STORAGE	0.00	6.18	0 10:09	0.00	
S_Baker	STORAGE	0.00	6.20	0 10:05	5.87	0 10:02
SE_Sump	STORAGE	2.46	2.46	0 10:06	0.69	0 10:05
SW_Sump	STORAGE	1.88	1.88	0 10:06	0.38	0 10:05

****
Storage Node Summary
****

Storage Node ID	Maximum Ponded Volume 1000 ft^3	Maximum Ponded Volume (%)	Time of Max Ponded Volume days hh:mm	Average Ponded Volume 1000 ft^3	Average Ponded Volume (%)	Maximum Storage Node Outflow cfs	Maximum Exfiltration Rate cfm	Time of Max. Exfiltration Rate hh:mm:ss	Total Exfiltrated Volume 1000 ft^3
Pond	76.847	4	2 23:43	69.696	4	0.00	0.00	0:00:00	0.000
S_Baker	1.928	100	0 09:58	0.334	17	0.05	0.00	0:00:00	0.000
SE_Sump	0.030	100	0 09:57	0.000	2	3.44	0.00	0:00:00	0.000
SW_Sump	0.030	100	0 09:59	0.002	5	2.88	0.00	0:00:00	0.000

****
Outfall Loading Summary
****

Outfall Node ID	Flow Frequency (%)	Average Flow cfs	Peak Inflow cfs
Out-01	0.00	0.00	0.00
System	0.00	0.00	0.00

****
Link Flow Summary
****

Link ID	Element Type	Time of Peak Flow Occurrence days hh:mm	Maximum Velocity Attained ft/sec	Length Factor	Peak Flow during Analysis cfs	Design Flow Capacity cfs	Ratio of Maximum /Design Flow	Ratio of Maximum Flow Depth	Total Time Surcharged minutes	Reported Condition
3-in_Return	CONDUIT	1 12:09	2.50	1.00	0.05	0.05	1.08	0.91	0	> CAPACITY
Link-04	CONDUIT	0 10:08	2.46	1.00	2.10	4.31	0.49	0.49	0	Calculated
Link-05	CONDUIT	0 10:08	3.89	1.00	4.00	6.48	0.62	0.57	0	Calculated
Link-09	CONDUIT	0 10:09	5.86	1.00	6.16	9.65	0.64	0.58	0	Calculated
S_Bkr_Pond	PUMP	0 09:58			0.05		1.00		1607	
SE_Sump_Pump	PUMP	0 10:05			3.44		0.04		520	
SW_Sump_Pump	PUMP	0 10:06			2.88		0.04		484	
Weir-01	WEIR	0 00:00			0.00		0.00			

****
Highest Flow Instability Indexes
****

Link SE_Sump_Pump (3)
Link SW_Sump_Pump (2)

****
Routing Time Step Summary
****

Minimum Time Step : 30.00 sec
Average Time Step : 30.00 sec
Maximum Time Step : 30.00 sec
Percent in Steady State : 0.00
Average Iterations per Step : 1.03

WARNING 107 : Initial water surface elevation defined for Junction Jun-SouthTank is below junction invert elevation.
Assumed initial water surface elevation equal to invert elevation.

WARNING 108 : Surcharge elevation defined for Junction Jun-SouthTank is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.

Analysis began on: Mon Jan 20 19:18:46 2014
Analysis ended on: Mon Jan 20 19:18:48 2014
Total elapsed time: 00:00:02

Golder Associates

Subject:	Leachate Calculations	Calculations Performed By:	JTK
Project No.:	130-1525	Calculations Checked By:	BCG
Project Description:	Recology Yuba-Sutter - Compost Area Leachate Collection Work Plan	Date:	01/27/14

Objective:

Determine estimated stormwater volumes used to help determine which type of storage or disposal system will feasibly work.

General Assumptions:

Total monthly precipitation depths for a 100-Yr return period are derived from a scaled factor from the difference between average and elevated conditions.
Evaporation losses assume a constant surface area based on the bottom contour for the pond sized for that storm return period.

Calculations:

Areas were measured using AutoCAD Civil 3D Version 2013. Table 1 summarizes these areas. Areas from Table 1 are used to perform calculations in Table 2 through 7.

Table 1: Area Measurements

Compost Area	Area Measurement (sf)	Subtotals (sf)	Subtotals (ac)
SUB 1	128,099		
SUB 2	100,757		
SUB 3	110,446		
SUB 4	97,537		
SUB 6	68,789		
Compost Area =		**505,628**	11.61
Pond Areas			
100-Yr RP Top Pond	187,933		4.31
100-Yr RP Bottom Pond	150,273		
Compost Pad + Large Pond =		**693,561**	15.92
Avg Annual RP Top Pond	75,024		
Avg Annual RP Bottom Pond	49,018		
Compost Pad +Avg Pond =		**580,652**	13.33
Peak 24-Hr Top Pond	46,583		
Compost Pad + Peak Pond =		**552,211**	12.68

Average precipitation depths were obtained from the Western Regional Climate Center for Marysville, CA[1]. The total annual precipitation depth for a 100-yr return period was obtained from California Department of Water Resources[2]. Table 2 presents the average monthly depths. The monthly depths for the 100-yr return period were obtained by multiplying each average monthly depth by the scale factor obtained by dividing the 100-yr annual total by the average annual total.

Table 2: Precipitation Depths

	Month												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Days/Month	31	30	31	31	28	31	30	31	30	31	31	30	365
Average Total Precipitation (in.)	1.21	2.44	3.76	4.01	3.73	2.88	1.53	0.75	0.22	0.03	0.06	0.34	20.96
Total Annual Precipitation for a 100 Yr Return Period (in) =													37.17
												Scale Factor	1.77
100-yr Elevated Total Precipitation (in.)	2.15	4.33	6.67	7.11	6.61	5.11	2.71	1.33	0.39	0.05	0.11	0.60	37.17

Precipitation run-off is calculated by multiplying the corresponding surface area for each row by the precipitation depth from Table 2. Table 3 presents the precipitation volumes in million gallons (Mgal).

Table 3: Precipitation Run-Off

	Month													
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (Mgal)	Total (ac-ft)
Avg Cond. Compost Area (Mgal)	0.38	0.77	1.19	1.26	1.18	0.91	0.48	0.24	0.07	0.01	0.02	0.11	6.61	20.27
100-yr Return Period Compost Area (gal)	0.68	1.36	2.10	2.24	2.08	1.61	0.86	0.42	0.12	0.02	0.03	0.19	11.72	35.95
Avg Cond. Pond (Mgal)	0.057	0.114	0.176	0.188	0.174	0.135	0.072	0.035	0.010	0.001	0.003	0.016	0.980	3.01
100-Yr Return Period Pond (Mgal)	0.25	0.51	0.78	0.83	0.77	0.60	0.32	0.16	0.05	0.01	0.01	0.07	4.35	13.36

Subject:	Leachate Calculations	Calculations Performed By:	JTK
Project No.:	130-1525	Calculations Checked By:	BCG
Project Description:	Recology Yuba-Sutter - Compost Area Leachate Collection Work Plan	Date:	01/27/14

Losses for make-up water are estimated using 15,000 gallons per day usage and assuming a 6 day per week work schedule. Total monthly volumes are calculated by multiplying the daily usage by the available number of days per month. Table 4 presents the make-up water usage for each month and an annual total.

Table 4: Make-Up Water Losses

	Month													
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (Mgal)	Total (ac-ft)
# work days (6 days/wk)	27	26	27	27	24	27	26	27	26	27	27	26		
Vol water for Make-Up (8k/day)	0.405	0.390	0.405	0.405	0.360	0.405	0.390	0.405	0.390	0.405	0.405	0.390	4.755	14.592
Make-Up Water Range	Minimum Monthly Usage =	360,000	gal											
	Maximum Monthly Usage =	405,000	gal											

Losses for evaporation were conservatively calculated using the area of the pond floor for the average annual and 100-Yr return period ponds. Monthly Pan evaporation depths are from the Western Regional Climate Center for Folsom Dam[3]. Losses for each month were calculated by multiplying the pan evaporation depth for each month by the appropriate pond area and using a 0.7 factor to account for differences between pan and actual evaporation. Table 5 presents evaporation losses for the two ponds analyzed.

Table 5: Evaporation Losses

	Month													
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (Mgal)	Total (ac-ft)
Pan Evaporation (inch)	**4.89**	**2.06**	**1.25**	**0.92**	**1.90**	**3.47**	**5.21**	**8.07**	**9.91**	**11.12**	**9.93**	**7.45**	**66.18 Inches**	
Evaporation Losses (Avg)	0.105	0.044	0.027	0.020	0.041	0.074	0.111	0.173	0.212	0.238	0.212	0.159	1.416	4.344
Evaporation Losses (100 Yr)	0.321	0.135	0.082	0.060	0.125	0.228	0.342	0.529	0.650	0.729	0.651	0.489	4.340	13.318

A preliminary water balance model was calculated by summing the inflows (precipitation: Table 3) and subtracting the losses (make-up water usage: Table 4 + evaporation: Table 5) for each month and summing the previous month to generate a cumulative water storage requirement. Table 6 presents the cumulative excess volume for each month after losses have been subtracted. The first and third rows show calculations based on the average and 100-yr return period with the corresponding pond sized for that storm event. The second row present totals for an average return period with a pond sized for a 100-yr return period.

Table 6: Water Balance

	Month													
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Peak Storage (ac-ft)	Peak Storage Required (cf)
Cumulative Vol. (Avg Yr incl Pond) (ac-ft)	0.00	1.38	4.23	7.38	10.30	12.02	12.18	11.25	9.64	7.70	5.87	4.57	12.18	530,769
Cumulative Vol. (Avg Yr, 4.3 ac pond) (ac-ft)	0.00	1.10	2.68	3.03	2.66	1.26	0.00	0.00	0.00	0.00	0.00	0.00	3.03	131,833
Cumulative Vol. (100-yr RP) (ac-ft)	0.62	4.75	12.10	20.11	27.40	32.23	33.59	32.48	29.81	26.40	23.30	21.40	33.59	1,463,026

Leachate disposal quantities based on tank storage or direct disposal were estimated for average conditions and a 100-Yr Return Period. Table 7 presents these calculations. Total volumes were derived from subtracting annual losses (Table 4) from annual precipitation (Table 3) for the corresponding storm event. Daily disposal rates were estimated by dividing the total volume by the total available work days for each storm return period. Similar calculations were perform for the peak monthly volumes using the highest precipitation month and diving that total calculated by the working days for that month.

Golder Associates

Subject:	Leachate Calculations	Calculations Performed By:	JTK
Project No.:	130-1525	Calculations Checked By:	BCG
Project Description:	Recology Yuba-Sutter - Compost Area Leachate Collection Work Plan	Date:	01/27/14

Table 7: Disposal Quantities

	Average Return Period	100-Yr Return Period
Annual Disposal Rates		
Total Volume (gal)	1,851,947	6,960,667
Total Workdays per year	317	317
Daily Disposal Rate (gal/day)	5,842	21,958
No. of 21,000 gal storage tanks required	89	332
Peak Disposal Rates		
Peak Monthly Volume	1,264,020	2,241,404
No. Workdays for peak month	27	27
Average Disposal rate (gal/workday)	46,816	83,015
Average Disposal rate (gpm)	97.53	172.95
No. of 21,000 gal storage tanks required	61	107

References:

1. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca5385
2. ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall%20Dept-Duration-Frequency/
3. http://www.wrcc.dri.edu/htmlfiles/westevap.final.html

APPENDIX B
TECHNICAL SPECIFICATIONS

SECTION 02080
LYSIMETER

PART 1 - GENERAL

1.01 SUMMARY

A. The vadose zone monitoring system work consists of furnishing all materials, tools, equipment, appliances, transportation, labor, and supervision required to install and document properly functioning pressure-vacuum lysimeters in the designated area.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D 1785-96 Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

2. ASTM D 2216-92 Laboratory Determination of Water (Moisture) Content of Soil and Rock

3. ASTM D 2488-93 Description and Identification of Soils (Visual-Manual Procedure)

4. ASTM D 4220-95 Preserving and Transporting Soil Samples

5. ASTM D 4696-92 Pore-Liquid Sampling from the Vadose Zone

6. ASTM D 4700-91 Soil Sampling from the Vadose Zone

7. ASTM F 480-95 Thermoplastic Well Casing Pipe and Couplings made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

1.03 DELIVERY, STORAGE AND HANDLING

A. Inspect all materials for the monitoring system upon their receipt at the site for conformance to project requirements and for defects or damage. Accept only materials found to be free from visible damage or defects and otherwise in good condition for use in the work.

B. Store and maintain all materials for the monitoring system in a clean, uncontaminated condition throughout the course of the work. Protect plastic components and assemblies from prolonged exposure to direct sunlight.

PART 2 – PRODUCTS

2.01 LYSIMETERS

A. Products required for the work include the lysimeter instrument itself and its appurtenances, and the other materials necessary to carry the sampling tubes to the ground surface and complete the installation. All materials shall be new and manufactured or supplied for applications of the type intended by this plan.

B. The lysimeter system consists of the following components:

1. Lysimeter: Pressure-vacuum type, designed for borehole installation, capable of retrieving fluid samples from depths of at least 150 feet, fitted with a ceramic cup having a nominal 2-bar bubbling pressure. Equal to Model 1940 High Pressure/ Vacuum Soil Water Sampler, as manufactured by Soil Moisture Equipment Corporation of Goleta, California.

2. Flexible Tubing: Polyethylene, manufactured for pressure/vacuum use, diameter to match lysimeter fittings. Furnish in two contrasting colors, one for the vacuum line and one for the pressure line. Equal to Product Nos. 1903L1000 and 1904L100, as supplied by Soil Moisture Equipment Corporation of Goleta, California.

3. Centralizers and Fittings: As needed to install lysimeter and to connect flexible tubing and PVC conduit to lysimeter.

4. Vacuum/Pressure Pump: Hand-operated, with 1-bar vacuum gauge, fittings for flexible tubing, and in-line filter, capable of generating 0.9 bar of vacuum and 75 psi (gage) of pressure. Equal to Model 2006G2 Pressure-Vacuum Hand Pump, as manufactured by Soilmoisture Equipment Corporation of Goleta, California.

2.02 OTHER MATERIALS

A. Other materials required to complete the installation include the following:

1. Conduit: Polyvinyl chloride (PVC), 2-inch nominal diameter, Schedule 40, conforming to ASTM D 1785, with flush-threaded male by female ends conforming to ASTM F 480.

2. Silica Flour: Passing No. 200 mesh. Equal to Product No. 0930W050, as supplied by Soilmoisture Equipment Corporation of Goleta, California.

3. Bentonite: Powdered sodium bentonite, without additives. Equal to Product No. 0920W050, as supplied by Soilmoisture Equipment Corporation of Goleta, California.

4. Protective Cover: Steel, lockable, casing or enclosure designed to be set over the surface at the PVC conduit end, with internal dimensions that allow easy access to the lysimeter tubing for system testing and sampling.

5. Additional Materials: Provide all other materials, supplies, or equipment reasonably required to satisfactorily complete the installation of an operational lysimeter at the location indicated.

PART 3 - EXECUTION

3.01 RESPONSIBILITIES

A. Contractor shall be responsible for trenching, backfilling and supply of PVC conduit, suitable backfill and bentonite.

B. Owner's Representative to supply vacuum lysimeter and silica flour and will connect lysimeter to PVC conduit.

3.02 PREPARATION

A. Prior to mobilizing to the site, inspect the lysimeter and soil moisture block components for damage and defects. Clean the lysimeters thoroughly in accordance with the manufacturer's instructions. Soak the ceramic cup for the lysimeter in an 8*N* solution of hydrochloric acid to remove impurities and flush it with distilled water in accordance with paragraph 7.4.1.1 of ASTM D 4696. Check the lysimeter for bubbling pressure, submit it to pressure and vacuum testing for leaks, and bag it for shipment to the site in accordance with sections 7.4.1.6 and 7.4.1.7 of ASTM D 4696.

B. Before installing the lysimeter at the site, saturate the ceramic cup in accordance with paragraph 7.4.1.7 of ASTM D 4696 and the manufacturer's instructions, and check lysimeter components for defects and damage.

3.03 GENERAL INSTALLATION

A. Excavate a hole to the dimensions and elevations shown on the Construction Plans. Place an 8-mil HDPE geomembrane in the hole prior to installing backfill material, the moisture blocks and the lysimeters. Install components in conformance with these specifications and the Construction Plans.

3.04 LYSIMETER INSTALLATION

A. Install the lysimeter in accordance with this section, the manufacturer's instructions, and ASTM D 4696. Connect the lysimeter to the flexible tubing in accordance with the manufacturer's instructions. Connect tubing of one color to the pressure/vacuum fitting and connect tubing of a contrasting color to the sample collection fitting. Maintain a written record of the tubing color used at each fitting type. Use clamp rings to connect the lysimeter to 2-inch-diameter PVC casing.

B. Perform a successful vacuum test on the completed lysimeter assembly before placing the tubing within the PVC conduit. Then thread the flexible tubing through the PVC conduit and connect the conduit lengths hand-tight. Do not use glues or adhesive materials to connect the conduit. Then place the lysimeter, tubing, and PVC conduit in the excavated trench along the base and up the slope.

C. Fill the lower 2 inches of the borehole with a slurry consisting of silica flour and deionized or distilled water. Place the lysimeter cup at the top of the slurry and hold it in position using the centralizer. Fill the annulus to approximately 6 inches below the top of the lysimeter (about 18 inches above the top of the porous cup) using silica-flour slurry placed through a 1-inch diameter tremie pipe. After allowing approximately 20 minutes for the slurry to firm up, place soil from the borehole cuttings in the annulus and hand tamped it to remove air voids. Fill the uppermost six inches of the annulus around the lysimeter with bentonite, using deionized or distilled water to hydrate the bentonite.

3.05 INITIAL LYSIMETER SAMPLING

A. Upon completion of lysimeter installation and removal of the water from the silica-flour slurry, attempt to collect a sample from the lysimeter. The lysimeter sampling protocol is as follows:

1. Two tubes lead from each lysimeter to the ground surface. One is a vacuum/pressure line and the other is a discharge line. A vacuum is applied to the lysimeter through the vacuum-pressure line and held for a minimum of 24 hours to allow moisture in the surrounding soils to be drawn into the lower chamber through a porous ceramic cup bonded to the end of the lysimeter.

2. As the lower chamber fills, the water (if present) is drawn into the upper chamber through a small tube and check valve, which remains open as long as a vacuum is applied. The discharge line is closed during this operation.

3. The sample is withdrawn from the upper chamber by releasing the vacuum, opening the discharge line, and applying pressure to the vacuum/pressure line. The pressure forces any water out of the upper chamber through the discharge line to the ground surface, where it is collected in sample bottles.

4. The initial sample (if any) is labeled, placed on ice, and transported to the laboratory. If no sample is recovered, note the fact for inclusion in the installation report described in paragraphs 1.04 and 1.05 of these specifications.

3.06 ACCEPTANCE

A. The lysimeters are not to be covered over by geosynthetic components until they have been sampled and are confirmed to operate according to manufacturer's recommendations.

B. The initial sampling will be monitored by the Owner/Engineer to verify the operation of the lysimeters. Upon demonstration of successful operation, the Owner/Engineer will authorize the lysimeters to be covered with base liner components.

END OF SECTION 02080

SECTION 02751

HDPE GEOMEMBRANES

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for the manufacture, supply, installation, and quality control (QC) of High Density Polyethylene (HDPE) geomembranes associated with the construction of the base liner system.

1.02 RELATED SECTIONS

A. Section 02756 – Geosynthetic Clay Layers

1.03 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D638 - Test Method for Tensile Properties of Plastics
2. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
3. ASTM D1004 - Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
4. ASTM D1204 - Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
5. ASTM D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
6. ASTM D1505 - Standard Test Method for Density of Plastics by Density-Gradient Technique
7. ASTM D1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
8. ASTM D3895 – Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry
9. ASTM D4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle Furnace Technique
10. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
11. ASTM D5321 - Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

12. ASTM D5397 – Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test

13. ASTM D5596 - Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

14. ASTM D5885 – Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry

15. ASTM D5994 - Standard Test Method for Measuring Core Thickness of Textured Geomembrane

16. ASTM D6392 - Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

17. ASTM D7007 – Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials

B. Latest version of Geosynthetics Research Institute (GRI) testing methods:

1. GRI-GM13 - Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

2. GRI-GM19 - Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

C. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

A. Production Data: Furnish the following in writing to the CQA Engineer a minimum of seven calendar days prior to geomembrane shipment to the site:

1. Resin:

   a. Statement of production dates and origin of resin used to manufacture the geomembrane for the project.

   b. Certification stating all resin is from the same manufacturer and that reclaimed polymer added to the resin during the manufacturing of the geomembrane does not exceed 10 percent by weight.

   c. Copies of the quality control certificates issued by the manufacturer and resin supplier indicating that the resin used to manufacture the geomembrane meets these specifications.

2. Quality Control: A copy of the manufacturer's quality control program shall be submitted to the CQA Engineer a minimum of seven calendar days prior to geomembrane shipment to the site. Quality control testing shall be performed by the manufacturer in accordance with the test procedures, and frequency listed in the Quality Control Program and as approved by the CQA Engineer. Prior to delivery the following shall be submitted to the CQA Engineer for Review:

a. Certificates for each shift's production of geomembrane, statements of production dates.

b. Certification stating all geomembrane rolls are furnished by one manufacturer, and all rolls are manufactured from one resin type obtained from one resin supplier.

c. Copies of quality control certificates issued by the Manufacturer. The quality control certificates shall include:

i. Roll numbers and identification

ii. Sampling procedures

iii. Results of quality control tests, including descriptions of the test methods used

d. The results of the manufacturing quality control tests shall meet or exceed the property values listed in Table 02751-1.

e. Geomembrane delivery, storage, handling and installation instructions.

3. Extrudate Beads and/or Rod:

a. Statement of production dates.

b. Certification stating all extrudate is from one manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane rolls.

c. Copies of quality control certificates issued by the Manufacturer.

B. Prior to mobilization of the Installer to the site, the Contractor shall submit the following information from Geosynthetic Installer:

1. Shop drawings indicating panel layout and field seams 14 calendar days prior to installation of geomembrane.

2. Installation schedule.

3. Copy of Installer's letter of approval or license by the Geomembrane Manufacturer.

4. Installation capabilities, including:

a. Information on equipment proposed for this project;

b. Average daily production anticipated for this project; and

c. Quality control procedures.

5. Copies of the quality control/quality assurance program for the manufacturer of the geomembrane liner.

6. Resume of the superintendent to be assigned to this project, including dates and duration of employment.

7. Resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment.

8. The installation crew shall have the following experience.

   a. The superintendent shall have supervised the installation of a minimum of 2,000,000 sf of polyethylene geomembrane and 500,000 sf of geotextile.

   b. The master seamer shall have experience seaming a minimum of 1,000,000 sf of polyethylene geomembrane using the same type of seaming apparatus to be used at this site.

   c. All other seaming personnel shall have seamed at least 100,000 sf of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 sf of polyethylene geomembrane shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

C. During the installation, the Installer shall be responsible for the timely submission to the CQA Engineer of subgrade acceptance certificates, signed by the Installer, for each area to be covered by geomembrane.

D. The Contractor shall furnish the Owner upon completion of the project:

1. A 20-year written warranty provided by the manufacturer against defects in material. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.

2. A 1-year warranty provided by the Geosynthetics Installer against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.

3. As-built Geomembrane Panel Drawings. As-built shall include panel locations, panel identification numbers, geomembrane roll numbers for each panel, seam caps, destructive sample locations, and large repairs.

1.05 QUALITY ASSURANCE

A. Perform work in accordance with the Installer's Quality Control Program and the Construction Quality Assurance Plan.

B. Attend a pre-installation conference one week prior to commencing work of this section. Require attendance of parties directly affecting the work of this Section.

PART 2: PRODUCTS

2.01 DELIVERY, STORAGE AND HANDLING

A. Conform to the manufacturer's requirements to prevent damage to geomembrane.

B. Delivery:

1. Deliver materials to the site only after the CQA Engineer and the Owner approve required submittals.

2. All rolls of geomembrane delivered to the site shall be identified at the factory with the following:

    a. Manufacturer's name

    b. Product identification

    c. Lot number

    d. Roll number

    e. Roll dimensions

3. Separate damaged rolls from undamaged rolls and store at locations designated by the Owner until proper disposition of material is determined by the Owner and the CQA Engineer.

4. The Owner will be the final authority regarding damage.

5. Separate rolls without proper documentation and store until the CQA Engineer approval is received.

C. On-Site Storage:

1. Store in space allocated by the Owner.

2. Protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage.

3. Store on level prepared surface (not on wooden pallets).

4. Stack per Manufacturer's recommendation but no more than three rolls high.

D. On-Site Handling:

1. Use appropriate handling equipment to load, move or deploy geomembrane rolls. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader and roll bars for deployment. Dragging panels on ground surface will not be permitted.

2. Do not fold geomembrane material; folded material shall be rejected.

3. The installer is responsible for storage, and transporting material from storage area to liner facility.

E. Damaged Geomembrane:

1. Geomembrane damage will be documented by the CQA Engineer.

2. Damaged geomembrane shall be repaired, if possible, in accordance with these specifications or shall be replaced at no additional cost to the Owner.

2.02 MATERIALS

A. The geomembrane shall be comprised of high density polyethylene (HDPE) material as indicated on the drawings, manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

B. The geomembrane shall be produced free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired in accordance with the repair procedures in Article 3.06.

C. The geomembrane shall be manufactured with a minimum of 15.0 feet seamless width. There shall be no factory seams.

D. The geomembrane liner shall be HDPE 60-mil and smooth as indicated on the drawings.

E. The geomembrane shall be supplied in rolls; folds will not be permitted. Identify each roll with labels indicating lot number, roll number, thickness, length, width, manufacturer, and plant location.

F. Specifications for HDPE geomembrane properties are presented in Table 02751-1 included at the end of this section. Supplied material shall conform to these properties based upon the manufacturer's QC testing and CQA conformance testing.

G. Resin:

1. Shall be HDPE, new, first quality, compounded and manufactured specifically for producing HDPE geomembrane.

2. Do not intermix resin types.

H. Extrudate Rod or Bead:

1. Shall be made from same resin as the geomembrane.

2. Additives shall be thoroughly dispersed.

3. Shall be free of contamination by moisture or foreign matter.

4. The texturing shall remain intact under the above test conditions (no peeling or shearing of the texturing).

2.03 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Equipped with gauges showing temperatures both in apparatus and at nozzle (extrusion welder) or at wedge (fusion welder).

2. Maintain adequate number of welding apparatus to avoid delaying work.

3. Use power source capable of providing constant voltage under combined-line load.

4. Provide secondary containment to catch spilled fuel under electric generator, if located on geomembrane.

B. Provide calibrated tensiometer capable of quantitatively measuring geomembrane strength:

1. Equipped with gauge accurate to +2 lbs per inch of geomembrane width and capable of pulling at 2 inches per minute and 20 inches per minute.

2. Provide one-inch die for cutting sample specimens.

3. Provide certificate of tensiometer calibration within the past 12 months.

2.04 CONFORMANCE TESTING

A. Material that arrives at the site will be sampled and conformance tested by the CQA Engineer at a minimum frequency of one per 150,000 square feet of material supplied to the project, with a minimum of one sample per production lot. Materials may be sampled at the plant at the option of the owner.

B. As a minimum, the following tests will be performed by a geosynthetics CQA laboratory and shall meet the requirements outlined in Table 02751-1.

1. Thickness (ASTM D5994)

2. Specific Gravity (ASTM D1505)

3. Carbon Black Content (ASTM D4218)

4. Carbon Black Dispersion (ASTM D5596)

5. Tensile Properties (ASTM D638)

6. Puncture Resistance (ASTM D4833)

C. If a test result is in non-conformance with the specifications, all material from that production lot represented by the failed test shall be rejected. Rejected material may be minimized by bounding the nonconformance material with additional passing tests conducted by the geosynthetics CQA laboratory. Additional tests shall be conducted at no additional cost to the Owner.

D. Rejected material shall be replaced at no additional cost to Owner.

PART 3: EXECUTION

3.01 EXAMINATION

A. Verify in writing that the surface on which the geomembrane will be installed is acceptable. In so doing the Installer shall assume full liability for the accepted surface.

B. The beginning of installation means acceptance of existing conditions. The Installer shall be responsible for maintenance of the geomembrane covered subgrade once installation of geomembrane begins.

3.02 PREPARATION

A. Maintain the surface suitability and integrity until the lining installation is completed and accepted.

B. Repair rough areas and any damage to the subgrade caused by installation of the liner.

C. To avoid sharp bends in the geomembrane, bevel the leading edges of the anchor trench.

D. Subgrade shall be smooth, uniform, firm and free from rocks or other debris. For deployment over soil subgrade, no rocks or protrusions greater than 1/2-inch in diameter shall be exposed at the subgrade surface.

3.03 DEPLOYMENT

A. Geomembrane shall not be deployed:

1. During precipitation;
2. In the presence of excessive moisture;
3. In areas of ponded water;
4. In the presence of excessive winds; or
5. In excessive heat or cold.

B. Each panel shall be marked with an "identification code" (number or letter) consistent with the layout plan. The identification code shall be simple and logical. The number of panels deployed in one day shall be limited by the number of panels which can be seamed on the same day. All deployed panels shall be seamed to adjacent panels by the end of each day.

C. The following is the acceptable method of deployment:

1. Use equipment which will not damage geomembrane by handling, trafficking, leakage of hydrocarbons or other means.

2. Do not allow personnel working on geomembrane to wear damaging shoes, or engage in activities that could damage geomembrane.

3. Smoking on the liner is prohibited.

4. Round sharp corners of clamps and other metal tools used in the work area.

5. Do not allow clamps and other metal tools to be tossed or thrown.

6. Unroll panels with a method that protects geomembrane from scratches and crimps and protects soil surface and underlying geotextile from damage.

7. Use a method to minimize wrinkles, especially differential wrinkles between adjacent panels.

8. Place adequate hold-downs to prevent uplift by wind.

9. Use hold-downs that will not damage geomembrane such as sandbags.

10. Use continuous hold-downs along leading edges to minimize risk of wind flow under panels.

11. Panels shall be deployed perpendicular to slope elevation contours and the generation of seams shall be minimized.

12. Protect geomembrane in heavy traffic areas by geotextile, extra geomembrane or other suitable materials.

13. Do not allow vehicular traffic on geomembrane surface.

14. Panels deployed on grades steeper than 12% shall extend a minimum of 3 feet beyond the crest or toe of that grade.

D. Visually inspect sheet surface during unrolling of geomembrane and mark faulty or suspect areas for repair or test. Replace faulty (requires more than one patch per 200 square feet) geomembrane stock at no additional cost to the Owner.

E. Deploy geomembrane in ambient temperatures less than 104□ F (40° C) and greater than 32° F (0° C), measured 6 inches above geomembrane surface. In prevailing warm or cold weather conditions deployment may be acceptable if the provisions for sampling in such conditions is satisfied (see Section 3.05 below). The geomembrane shall not be deployed during precipitation, in the presence of excessive moisture, in area of ponded water, or in the presence of excessive winds.

3.04 FIELD SEAMING

A. Orient seams perpendicular to slope elevation contours, i.e., orient down (not across) slope and use seam numbering system compatible with panel number system.

B. Minimize the number of field seams in corners, odd-shaped geometric locations and outside corners.

C. Overlap panels by a minimum of 3 inches for extrusion welding and 4 inches for fusion welding. Use procedures to temporarily bond adjacent panels together that do not damage the geomembrane and that are not detrimental to seam weld material for extrusion welding.

D. Do not use solvent or adhesive unless product is approved in writing by the Owner.

E. No horizontal seams shall be allowed on grades steeper than 12% or within 3 feet of the crest or toe of slopes. A horizontal seam is defined as more than half of the panel width.

F. Clean surface of grease, moisture, dust, dirt, debris or other foreign material.

G. Prior to any extrusion welding, the geomembrane seam or repair shall be prepared as follows:

1. Clean surface of oxidation by disc grinder or equivalent not more than one hour before seaming; use number 80 grit sandpaper for the disc grinder. Bevel edges of geomembrane before bonding and provide continuous tacking in repair areas.

2. Repair area where excessive grinding substantially reduces sheet thickness by more than 4 mils beyond extents of weld.

3. Clean grinding dust around weld area after grinding.

4. The following procedure shall be followed for wrinkles and fishmouths.

   a. Cut along the ridge of the wrinkle or fishmouth.

   b. Overlap a minimum of 3 inches and seam.

   c. Any portion where the overlap is less than 3 inches shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 inches beyond the cut in all directions.

5. If required, a firm, dry substrate (piece of geomembrane or other material) may be placed directly under the seam overlap to achieve proper support.

6. Keep water from intercepting the weld during and immediately after welding the seam.

7. For existing welds, or welds that are over 3 minutes old, grind the existing weld two inches back from point of termination and restart welding on ground weld.

H. At least one spare operable seaming apparatus shall be maintained for every three seaming teams. Place protective fabric or piece of geomembrane beneath hot welding apparatus when resting on geomembrane lining and use an electric generator capable of providing constant voltage under combined line load. The electric generator shall generally be located outside of liner. Provide protective lining and secondary containment large enough to catch spilled fuel under electric generators when located on the liner. The welding apparatus shall be equipped with gauges giving temperatures in apparatus and at nozzle.

I. For extrusion welding, purge welding apparatus of heat-degraded extrudate before welding if extruder is stopped for longer than five minutes. All purged extrudate shall be disposed of off the geomembrane. Each extruder shoe shall be inspected daily for wear to assure that its offset is the same as the geomembrane thickness. Repair or replace worn shoes, damaged or misaligned armature brushes, nozzle contamination, or other worn or damaged parts. Avoid stop-start welding. Remove extrudate rod from welder when not using welder for long period (over two hours). No welding may commence on the liner until the field trial seam sample, made by that equipment and seamer, passes destructive testing.

J. Test and set "hot air system" using scrap material at least each day prior to commencing seaming and adjust hot air velocity to preclude wind effects. Adjust contact pressure rollers to prevent surface ripples in sheet. No equipment shall be used for welding the geomembrane until a field trial seam sample made by that equipment has passed destructive testing.

K. In performing hot wedge welding, the welding apparatus shall be automated vehicular mounted devices equipped with gauges giving applicable temperatures and pressures. The edge of cross seams shall be ground to smooth incline (top and bottom) prior to welding. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage. Protect against moisture buildup between sheets. If welding across cross seams, conduct field test seams at least every two hours, otherwise once prior to start of work and once at mid-day. No equipment is allowed to commence welding on geomembrane until the field trial seam sample made by that equipment has passed destructive testing.

L. Field trial seams shall be conducted, per seaming apparatus and per seamer, on pieces of geomembrane liner to verify adequate seaming conditions at the following frequency:

1. At beginning of each seaming period.
2. At least once every five hours.
3. At the discretion of the CQA Engineer.

M. Make the trial seams at area of seaming and in contact with subgrade (same condition as the liner to be seamed). The seam sample shall be at least 42 inches long and 12 inches wide with the seam centered lengthwise. A one foot length of each trial seam sample shall be submitted to the CQA Engineer for archive. Cut three 1-inch wide specimens and test two for peel adhesion, and one for bonded seam strength (shear). Each double wedge fusion seam specimens shall be tested for peel on both sides of the weld. A specimen passes when:

1. The locus-of-break is not one of the following failing modes as defined by ASTM D6392:

    a. An adhesion failure (code AD, AD1 or AD2),

    b. Greater than 25% adhesion failure on an adhesion-break (code AD-BRK), or

c. An adhesion-weld break through an extrusion weld which exhibits a strength less than required by Table 02751-2

2. The break is ductile.

3. The strength of breaks for the trial seam testing shall conform to the values listed in Table 02751-2, included at the end of this section.

N. A trial seam sample passes when all three specimens have passing results in peel and shear tests. If a specimen fails (one of the specimens fails in either peel or shear mode), the trial seam procedure shall be repeated in its entirety. If the repeated trial seam fails, the seaming apparatus or operator may not weld until the deficiencies or conditions are corrected and two consecutive passing field trial seams are achieved.

O. The following procedures shall be followed during cold weather conditions.

1. Geomembrane surface temperatures shall be determined by the CQA Engineer at intervals of at lease once per 100 feet of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32°F (0°C).

2. For fusion welding, preheating may be waived by the Owner based upon a recommendation by the CQA Engineer, if the installer demonstrates to the CQA Engineer's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the CQA Engineer will observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.

4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.

5. All preheating devices shall receive approval by the CQA Engineer prior to use.

6. Additional destructive tests will be taken at an interval between 250 and 500 feet of seam length, at the discretion of the CQA Engineer.

7. Sheet grinding may be performed before preheating, if applicable.

8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10°F from the initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during the temperature drop.

P. The following procedures shall be followed during warm weather conditions.

1. At ambient temperatures above 104°F (40°C), no seaming of the geomembrane shall be permitted unless the Installer can demonstrate to the satisfaction of the

CQA Engineer that the geomembrane seam quality is not compromised. Trial seaming shall be conducted under the same ambient temperature conditions as the production seams. At the option of the CQA Engineer, additional destructive testing may be required for any suspected areas.

3.05 FIELD QUALITY CONTROL

A. The Installer shall designate a full-time quality control (QC) technician who shall be responsible for supervising and/or conducting the field quality control program. The QC technician may not be replaced without written authorization by the Owner.

B. Non-Destructive Seam Testing

1. The Installer shall non-destructively test field welds for continuity over their full length using vacuum test units. The non-destructive testing shall be performed concurrently with seaming work progress, not at the completion of all seaming. Any defects located in the seam shall be repaired in accordance with Section 3.06. The following non-destructive testing procedures shall be used to test the field seams for continuity.

a. Vacuum box testing for extrusion welds.

b. Air pressure testing for double fusion seams.

2. Vacuum Box Testing

a. The vacuum box testing equipment shall comprise the following.

i. Rigid housing; transparent viewing window; a soft rubber gasket attached to bottom of housing; porthole or valve assembly; and a vacuum gauge.

ii. A vacuum pump capable of applying 5 psi gage pressure of vacuum to the box.

iii. A bucket of soapy solution and applicator.

b. The procedure for vacuum testing is as follows:

i. Clean window, gasket surfaces, and check for leaks.

ii. Energize vacuum pump and reduce tank pressure to approximately 5 psi.

iii. Wet a strip of geomembrane approximately 12 inches by 30 inches (or length of box) with soapy solution.

iv. Place box over wetted area and compress.

v. Close bleed valve and open vacuum valve.

vi. Ensure that a leak tight seal is created.

vii. Examine length of weld through viewing window for presence of soap bubbles for a period of not less than 10 seconds.

viii. If no bubbles appear after 10 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three inches overlap and repeat process.

ix. Areas where soap bubbles appear will be marked by the CQA Engineer with a defect code. The Installer shall then repair the area in accordance with Section 3.06 and retest the repaired area.

3. Air Pressure Testing (Double Fusion Seams Only)

a. The air pressure testing equipment shall comprise the following.

i. An air pump, equipped with pressure gauge having an accuracy of 1 psi, capable of generating and sustaining a pressure between 25 to 30 psi and mounted on a cushion to protect geomembrane.

ii. Rubber hose with fittings and connections.

iii. Sharp hollow needle or other pressure feed device approved by the Owner.

b. To perform the test:

i. Seal both ends of the seam to be tested.

ii. Insert a needle or other approved pressure feed device into tunnel created by double hot wedge seaming and insert a protective cushion between air pump and geomembrane.

iii. Energize air pump to 25 to 30 psi, close valve, and sustain pressure for a minimum of five minutes.

iv. If loss of pressure exceeds 2 psi or does not stabilize, locate faulty area and repair in accordance with Section 3.06.

v. Release pressure at opposite end of seam from gauge to verify that the seam is not blocked.

vi. Remove approved pressure feed device and seal penetration holes by extrusion welding.

C. Destructive Seam Testing

1. For destructive seam testing, the CQA Engineer shall be provided with a minimum of one sample per 500 feet of seam length by each welding apparatus. The location will be selected by the CQA Engineer and the installer will not be informed of the sample location in advance. The installer shall visually observe, mark and repair suspect welds before release of a section to the CQA Engineer for destructive sample marking. Cut destructive samples as seaming and

nondestructive testing progresses, prior to completion of liner installation. The CQA Engineer will mark destructive samples with consecutive numbering, location, apparatus I.D., technician I.D., Engineer I.D., and apparatus settings and date. Record, in written form, weld and test date, time, location, seam number, ambient temperatures, machine settings, technician I.D., apparatus I.D., and pass or fail description. The installer shall immediately repair holes in geomembrane resulting from obtaining destructive samples and vacuum test patches. The size of destructive samples shall be 12 inches wide by 48 inches long with seam centered lengthwise.

2. Two 1-inch wide specimens shall be taken from each side of the sample and tested by the Installer for peel and shear in the field prior to CQA destructive testing. If any of these specimens fail, the Installer shall track the failure immediately. The remaining sample shall be cut into three 14-inch long pieces and distributed as follows:

   a. To the CQA Engineer for destructive testing.

   b. To the CQA Engineer for archive.

   c. To the Installer for its use.

3. Ten 1-inch wide specimens shall be taken from one piece. Five specimens shall be tested for peel and five for shear strengths in accordance with the CQA Plan, with test results meeting the requirements of Table 02751-2, included at the end of this section. In the event of failure, the procedures for failed seam tracking are:

   a. Retrace welding path a minimum of 10 feet in both directions from the failed test location and remove (at these locations) a one inch wide specimen for testing. Repeat tracking procedures until the Installer is confident of seam quality.

   b. Obtain destructive samples from each side of the welding path and give samples to the CQA Engineer for destructive testing.

   c. Repeat process if additional tests fail.

   d. Reconstruct seam between passing test locations to satisfaction of the CQA Engineer.

   e. Reconstruction may be one of the following:

      i. Cut out old seam, reposition panel and re-seam.

      ii. Add cap strip.

   f. Cut additional destructive samples from reconstruction at discretion of CQA Engineer.

   g. If additional destructive sample results are not acceptable, repeat process until reconstructed seam is judged satisfactory by the CQA Engineer.

D. For final seaming inspection, check the seams and surface of geomembrane for defects, holes, blisters, undispersed raw materials, or signs of contamination by foreign matter. Brush, blow, or wash geomembrane surface if dirt inhibits inspection. The CQA Engineer shall decide if cleaning of geomembrane surface and welds is needed to facilitate inspection. Distinctively mark repair areas and indicate required type of repair.

3.06 REPAIR PROCEDURES

A. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Installer if surface contamination inhibits inspection. The Installer shall ensure that an inspection of the geomembrane precedes any seaming of that section.

B. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

C. Repair, removal and replacement shall be at the Subcontractor's expense if the damage results from the installer's, or the Subcontractor's sub-subcontractor activities.

D. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. The Installer shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate repair method shall be decided between the CQA Engineer and the Installer. Procedures available include:

1. Patching: Used to repair holes (over 1/4-inch diameter), tears (over 1/4 inch long), undispersed raw materials, and contamination by foreign matter.

2. Grinding and welding: Used to repair pinholes, blemishes and over-grinding.

3. Capping: Used to repair large lengths of failed seams.

4. Removing the seam and replacing with a strip of new material.

E. In addition, the following procedures shall be observed.

1. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.

2. All geomembrane surfaces shall be clean and dry at the time of repair.

3. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA Engineer.

4. Extend patches or caps at least 6 inches beyond the edge of the defect, i.e., be a minimum of 12 inches in diameter, and round all corners of material to be patched.

5. Bevel the edge of the patch and do not cut patch with repair sheet in contact with geomembrane. Temporarily bond the patch to the geomembrane with an approved method, extrusion weld the patch and then vacuum test the repair.

F. Repair Verification:

1. Number and log each patch repair (performed by the CQA Engineer).

2. Non-destructively test each repair using methods specified in this Section.

3. Provide daily documentation of non-destructive and destructive testing to the CQA Engineer. The documentation shall identify seams that initially failed the test and include the evidence that these seams were repaired and retested successfully.

3.07 PREPARATION FOR ELECTRICAL LEAK LOCATION SURVEY

A. Preparation for the Electrical Leak Location Survey (ELLS) consists of all work necessary to prepare the liner system for an ELLS in accordance with ASTM D 7002. Preparations for the ELLS shall be completed as follows:

1. The Contractor shall provide a water truck and driver to add water to the exposed geomembrane during the ELLS to maintain moisture in these layers. This water application shall be at the direction of the ELLS firm.

2. The ELLS firm shall furnish and the Installer shall install permanent electrodes within the low-permeability soil layer prior to the installation of the primary geomembrane. The end(s) of the wires leading to the electrodes shall be made accessible to the ELLS Surveyor at the time of the ELLS.

3. The Contractor shall supply an AC power source for the ELLS (110V, 5A).

4. The Contractor shall supply two supervised laborers with equipment to assist with laying out the survey string lines and wetting the survey area.

5. The ELLS is expected to take up to 2 working days to complete. The Contractor shall allow for time necessary to complete the survey.

B. If the ELLS identifies potential damages and/or leaks in the liner, the Contractor is responsible for all work and costs necessary to expose the liner, repair the damages or leaks in the liner, and reconstruct the necessary layers of the liner system.

3.08 ACCEPTANCE

A. The Subcontractor shall retain ownership and responsibility for the geomembrane until acceptance by the Owner.

B. Acceptance Criteria: The following shall be completed:

1. Verification of adequacy of field seams, repairs and testing by the CQA Engineer.

2. Electrical Leak Location Survey (ELLS) in accordance with Section 3.07 and the CQA Plan.

3. All submittals.

4. "As-built" drawings, approved and final drawings submitted.

5. Construction area cleaned.

6. Final field inspection

7. Warranty signed over to the Owner.

C. Field Inspections: Inspect the completed work with the Owner; defects, wrinkles, suspicious looking welds shall be noted and marked; document, correct and arrange further field inspections until no corrective action is necessary.

END OF SECTION

TABLE 02751-1

HDPE GEOMEMBRANE PROPERTIES

Property	Qualifier	Units	Specification	Test Method
Thickness	min.	mils	60	ASTM D5199[1]
	average	mils	54	
	minimum			
Density		g/cc	0.940	ASTM D792/D1505
	min. avg.			
Carbon Black Content		%	2 - 3	ASTM D4218
Carbon Black	range	-	Category	ASTM D5596[2]
Dispersion	rating		1,2,&3	
				ASTM D6693 [3]
Tensile Properties		lb/in		
1. Yield Strength	min. avg.	lb/in	126	
2. Break Strength	min. avg.	%	90	
3. Elongation at Yield	min. avg.	%	12	
4. Elongation at Break	min. avg.		100	
		lb		ASTM D1004[4]
Tear Resistance	min. avg.		42	
		lb		ASTM D4833
Puncture Resistance	min. avg.		90	
Oxidation Induction		minutes		ASTM D3895
Time	min. avg.	% retained	100	ASTM D3895[5]
1. Standard, or		minutes	55	ASTM D5885
	min. avg.	% retained	400	ASTM D5885[5]
2. High Pressure			80	
		hours		ASTM D5397[6]
	min. avg.		300	
Stress Crack Resistance				

1. 10 measurements across the width of the roll (perpendicular to the machine direction) and report average and lowest individual readings.
2. At least 9 specimens will be Category 1 or 2. No more than one specimen shall be Category 3. No specimen shall be Category 4 or 5.
3. Type IV die. ASTM D638 test specimen shall be used.
   a) The grip separation shall be 2.5 inches. This test does not require the use of extensometers. The rate of grip separation will be 2 inches per minute.
   b) Machine Direction (MD) and Transverse Direction (TD) average values should be on the basis of 5 test specimens in each direction.
   c) Yield elongation is based on a gauge length of 1.3 inches. Break elongation is based on a gauge length of 2.0 inches.
4. Die C
5. Percent retained after 90 days.
6. a) P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough

surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.

b) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

TABLE 02751-2

HDPE GEOMEMBRANE SEAM PROPERTIES

PROPERTY	QUALIFIER	UNITS	SPECIFICATION	METHOD
Shear Seam Strength [1,2]	minimum	lb/in.	120	ASTM D6392(1)
Shear Seam Elongation [3]	minimum	%	50	ASTM D6392(2)
Peel Adhesion [1,2]				
Fusion Strength	minimum	lb/in.	91	ASTM D6392(1)
Extrusion Strength	minimum	lb/in.	78	ASTM D6392(1)
Peel Separation	maximum	%	25	ASTM D6392(1)

1. For shear tests, the sheet shall yield before failure of the seam. For either test, testing shall be discontinued when the sample has visually yielded. Sample break shall conform to a passing locus-of-break as described in paragraph 3.04.M.1 of this Section.
2. Value or mode for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen value can be as low as 80% of the listed values.
3. Elongation measurements shall be omitted for field testing.

SECTION 02756
GEOSYNTHETIC CLAY LINER

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for the manufacture, supply, installation, and quality control of the geosynthetic clay liner (GCL) associated with the construction of the base liner system.

1.02 RELATED SECTIONS

A. Section 02200- Earthwork

B. Section 02751 – HDPE Geomembranes

1.03 REFERENCES

A. American Society of Testing and Materials (ASTM), latest edition:

1. ASTM D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

2. ASTM D5084 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter

3. ASTM D5887 Standard Test Method for Measurement of the Index Flux through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter

4. ASTM D5888 Standard Guide for Storage and Handling of Geosynthetic Clay Liners

5. ASTM D5889 Standard Practice for Quality Control of Geosynthetic Clay Liners

6. ASTM D5890 Standard Test Method for Swell Index Measurement of Clay Component of Geosynthetic Clay Liners

7. ASTM D5993 Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners

8. ASTM D6141 Standard Guide for Screening the Clay Portion of a Geosynthetic Clay Liner (GCL) for Chemical compatibility to Liquids

9. ASTM D6243 Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the

Direct Shear Method

10. ASTM 6496 Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners

11. ASTM 6768 Standard Test Method for Tensile Strength of Geosynthetic Clay Liners

B. Latest version of Geosynthetics Research Institute (GRI) testing methods:

1. GRI-GCL3 - Test Methods, Required Properties, and Testing Frequencies for Geosynthetic Clay Liners (GCLs)

1.04 SUBMITTALS

A. Quality Control Submittals:

1. A copy of the Manufacturer's quality control plan.

2. Quality control (QC) certificates containing the Manufacturer's QC testing results. At a minimum, QC certifications shall include the requirements listed in Part 2.01 B of this section. QC certificates shall be submitted at a the frequency indicated in the Manufacturer's QC Plan for GCL continuously produced and supplied to the project and at least one per lot.

3. Manufacturer's certificate that products meet or exceed specified requirements.

1.05 QUALITY ASSURANCE

A. Perform work in accordance to the Construction Quality Assurance Plan.

1.06 QUALIFICATIONS

A. The Contractor shall be experienced in this installation of geosynthetic clay liners. In the event the Contractor is not experienced, a Representative of the Geosynthetic Clay Liner Manufacturer shall be on site to train the Contractor, at no additional cost to the Owner.

PART 2: PRODUCTS

2.01 GEOSYNTHETIC CLAY LINER (GCL)

A. GCL Materials. The GCL shall consist of Bentomat DN or equivalent and shall include internal stitching reinforcement through the material that joins the backing fabrics.

B. The GCL shall meet or exceed the product specifications below:

1. Maximum moisture content of 12% at the time of manufacture per ASTM D4643. The GCL shall not be installed with a moisture content greater than 35%.

2. Maximum fluid loss of 18 ml per ASTM D5891.

3. Nominal Thickness: 0.25 inches.

4. Maximum permeability of $5x10^{-9}$ cm/sec per ASTM D5084.

5. Bentonite mass per unit area of 0.75 lbs/ft^2 at 0% moisture (0.95 lbs/ft^2 at 20% moisture) per ASTM D5993.

2.02 DELIVERY, STORAGE, AND HANDLING

A. Handling, storage, and care of the geosynthetic clay liner, prior to and following installation, is the responsibility of the Contractor, until Final Acceptance of the liner system by the Owner.

B. Store and protect the geosynthetic clay liner. GCL shall be protected from ultraviolet light exposure, moisture, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Manufacturer shall be the Contractor's responsibility.

C. Protect GCL from rain and moisture at all times.

D. All rolls of GCL shall be identified at the factory with the following:

1. Manufacturer's name

2. Product identification

3. Lot number

4. Roll number

5. Roll dimensions

E. GCL rolls shall be shipped and stored in relatively opaque and water tight wrappings.

2.03 CONFORMANCE TESTING

A. Conformance testing shall be completed at a frequency of 1 test per 100,000 square feet of material delivered to the site, and a minimum of 1 test per lot.

B. Conformance tests shall include permeability (ASTM D 5084) and mass per unit area (ASTM D 5993).

PART 3: EXECUTION

3.01 INSTALLATION

A. Repair rough areas and any damage to the subgrade caused by installation of the lining and fill any ruts caused by equipment prior to overlying geomembrane deployment.

B. Install the GCL so that panel seams are parallel to the dip of the slope.

C. Pull GCL panels from roll suspended at the crest of the slope and install with the non-woven geotextile side up or as recommended by the Manufacturer.

D. Do not install the GCL over wet subgrade, in standing water, or during precipitation events. Geomembrane shall not be placed on a GCL that is hydrated.

E. The GCL shall be overlapped in accordance with the Manufacturer's recommended procedures. As a minimum, the overlap shall be a minimum of 6 inches (12 inches maximum) along the length of the GCL panel and 12 inches along the ends of the GCL panel.

F. Place only as much GCL each day as can be covered with HDPE liner. The GCL shall be covered by HDPE liner at the end of each working day.

G. Use single panels of bentonite mat from anchor trench over crest of slope down to lower limit of mat on an intermediate bench or cell floor.

H. End-to-end seams only allowed on slopes of 10 percent or less.

I. Do not drag textured geomembranes across previously installed bentonite mat. Use a smooth rub sheet between mat and geomembrane, or other methods, to prevent damage. Remove rub sheet when geomembrane is in position.

J. All hydrated GCL shall be removed and replaced by the Contractor at no additional cost to the Owner.

3.02 GCL SEAMING

A. Pull bentonite mat tight to smooth out creases or irregularities in the panels.

B. Remove all dirt and debris from the overlap area.

C. Bentonite seam enhancement, consisting of the placement of 0.50 lbs/ft^2 of dry bentonite between overlapped panels, shall be completed for all seams except for the following conditions:

1. The edge-to-edge panel seams consist of Bentomat DN with super groove seams.

D. Seams shall consist of overlap and bentonite. All seams shall be also heat bonded.

3.03 REPAIR

A. Repair cuts, tears, or holes in the GCL by covering with a geosynthetic clay liner patch. On slopes greater than 5 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 ft in all directions. On slopes 5 percent or flatter, the patch shall overlap the edges of the hole by a minimum of 1 ft in all directions and 0.50 lbs. / ft^2 of raw bentonite.

B. Attach patch to panel using either non-hazardous, non-toxic adhesive as recommended by GCL manufacturer or by spot welding with hot air apparatus ("Leistering"). Attachment method shall be approved by Construction Manager (based on recommendations of the CQA Engineer) prior to use.

C. All repairs shall be made at no additional cost to the Owner.

- END OF SECTION -